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ABSTRACT

Specifically, the problem which this research addresses is the development of procedures which define the relational attributes to words in English text. These relational attributes are considered an essential part of any good index and therefore an antecedent to the production of good indexes by automated means. The organization of this dissertation is as follows: Chapter I presents an overview of theories of language. Chapter II presents a theoretical framework for an empirical investigation of language. Chapter III presents procedures for the identification of relational attributes among words in English text. Chapter IV describes procedures for the identification and characterization, in relational terms, of clauses and phrases in text. Chapter V presents procedures for the assignment of case roles. These case roles amount to functional interpretation of text elements (e.g., phrases). Chapter VI relates the language analysis procedures presented in earlier chapters to the notion of indexing and proposes a graphical representation of English text as a general base from which a variety of indexes may be automatically derived. Chapter VII contains a brief statement of conclusions and of direction for future research. A KWIC index of the references cited is included in Appendix F. (Author/NH)

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# DEVELOPMENT OF LANGUAGE ANALYSIS PROCEDURES WITH APPLICATION TO AUTOMATIC INDEXING

by

Carol Elizabeth Young

Work performed under
Grant No. 534.1, National Science Foundation

Computer and Information Science Research Center
The Ohio State University
Columbus, Ohio 43210
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# PREFACE

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The Computer and Information Science Research Center of The Ohio State University is an interdisciplinary research organization which consists of the staff, graduate students, and faculty of many University departments and laboratories. This report is based on research accomplished in cooperation with the Department of Computer and Information Science.

The research was administered and monitored by The Ohio State University Research Foundation.

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# STATEMENT OF THE PROBLEM

The problem addressed in this research is one that has received the attention of many people. It is this: "Is it possible to develop computer programs which operate upon written English so as to produce a form of representation that makes possible the generation of high quality indexes by automated means?" Automated indexing procedures have been largely relegated to the tasks of sorting, formatting and printing, while the substance of the index is manually derived. Thus the question is one of how to derive good, meaningful indexes from documents automatically rather than manually.

Specifically, the problem which this research addresses is the development of procedures which define the relational attributes to words in English text. These relational attributes are considered an essential part of any good index and therefore an antecedent to the production of good indexes by automated means.

The organization of this dissertation is as follows:

Chapter I presents an overview of theories of language.

Chapter II presents a theoretical framework for an empirical investigation of language.

Chapter III presents procedures for the identification of relational attributes among words in English text.

Chapter IV describes procedures for the identification and characterization, in relational terms, of clauses and phrases in text.

Chapter V presents procedures for the assignment of case roles. These case roles amount to functional interpretation of text elements (e.g., phrases).

Chapter VI relates the language analysis procedures presented in earlier chapters to the notion of indexing and proposes a graphical representation of English text as a general base from which a variety of indexes may be automatically derived.

Chapter VII contains a brief statement of conclusions and of direction for future research.

Finally, a KWIC index of all the references cited in this dissertation is included as a way of making parts of the dissertation accessible by other than sequential means. This index is given in Appendix F.

# CHAPTER I. OVERVIEW OF THEORIES OF LANGUAGE

> A language is a set of principles relating meanings and phonetic sequences.
>
> R. W. Langacker, Fundamentals of Linguistic Analysis

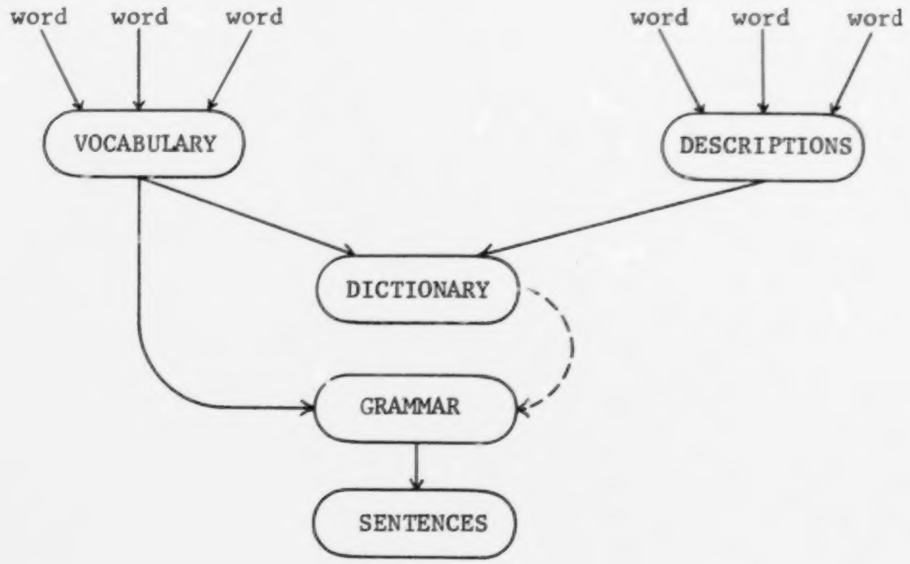
> A language is any set of sentences over an alphabet. A sentence over an alphabet is any string of finite length composed of symbols from the alphabet. An alphabet or vocabulary is any finite set of symbols.
>
> J. E. Hopcroft and J. D. Ullman, Formal Languages and their Relation to Automata

> English, n., A language so haughty and reserved that few writers succeed in getting on terms of familiarity with it.
>
> A. Bierce, The Enlarged Devil's Dictionary

## 1. Introduction

Printed or written language consists of a set of elements called words. This set of words is the vocabulary of the language. A dictionary is a collection of vocabulary elements along with a description of each element. The permissible ways in which vocabulary elements may be strung together (i.e., arranged in a linear sequence) is governed by a set of rules called a grammar. The resulting sequence may be called a sentence. The set of sentences permitted by the grammar constitute a language (1), (see Figure 1.1).

While the derivation and definition of words is of interest, especially to the lexicographer, etymologist, historical linguist and sociolinguist, only a small part of modern linguistic effort is directed toward the study of words. Most attention has been paid to the grammar,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DESCRIPTIONS
DICTIONARY
GRAMMAR
SENTENCES

Figure 1.1 Illustration of various concepts which comprise the notion of "language."

or grammars, of a language, for the most part because the grammars of natural languages are still largely intuitive and difficult to describe precisely.

## 2. Traditional (Pedagogical) Grammar

> Grammar describes the relationships which words bear to one another in a statement.
>
> J. Moffat, The Structure of English

Traditional grammar has been viewed as a model which dictates the form of language. A sentence construction was, within the context of this model either right or wrong, and grammar books contain the last word on the validity of a string of words as a sentence. The traditional grammar model has been handed down for centuries as something not to be questioned. Let us consider how this model came into being.

The study of language can be traced back to the Greeks of the 5th century B.C., when language was studied from philosophical perspectives. Language was believed to contain the universal forms of thought. Syntactic forms of the language were derived and were defined in accordance with the philosophical significance of each form. The Greek theories were developed through an investigation of the processes governing thought and action (2).

The parallel between this model of grammar which developed at such an early period and our current traditional grammar is great. Here are some of the steps in the development of Greek grammar. Plato, in one of his dialogues, classified nouns and verbs on logical grounds. Aristotle identified nouns, verbs and conjunctions (although the use of the latter term differs from its current use). The Stoics added a class of articles and examined number, voice, mood and case (nominative, vocative, accusative, genitive and dative). Dionysios Thrax, an Alexandrian scholar of the 1st century B.C., recognized eight parts of speech: noun, verb, participle, article, pronoun, preposition, adverb and conjunction. Remmius Palaemon added the interjection as a part of speech in the first century A.D. This classical grammar survived in over a thousand manuscripts and it formed the basis of the Latin grammar recorded in the eighteenth century (3).

In the process of writing down an English grammar, early grammarians were influenced by logic and by Latin grammar. To scholars of the 18th century a correct sentence had to be logically correct. Thus, a rule was put forth that words like "perfect," "round" and "square" could not have a comparative degree. If a thing is perfect, it can not be more perfect since one cannot reach beyond perfection. If a thing is round, it is already round and cannot become rounder. A modern linguist would agree neither with the initial hypothesis nor with the outcome.

Latin grammar was a major factor in the formation of an English grammar. The transference of Latin rules to English rested on the theory that all languages had a common structure. As a result, traditional grammar books refer to accusative and dative cases when there is no need for them in English; to gender in nouns when gender in English nouns is a part of their meaning; and to the restriction from placing a preposition at the end of a sentence when this is not always possible (4)[1]. While such attributes are important (e.g., in the investigation of the derivation of English from Latin), these attributes are not relevant to the definition of a grammar of English.

## 3. Contemporary Approaches to a Grammar of English

> The grammar of a language is a system of rules that determine a certain pairing of sound and meaning. It consists of a syntactic component, a semantic component and a phonological component.
>
> N. Chomsky, Aspects of the Theory of Syntax

> Formally, we denote a grammar G by $(V_N, V_T, P, S)$. The symbols $V_N$, $V_T$, P and S are, respectively, the variables, terminals, productions and start symbol.
>
> J. E. Hopcroft and J. D. Ullman, Formal Languages and their Relation to Automata

While traditional grammar has apparently been adequate for pedagogical purposes, its inadequacies for other purposes became acutely apparent in the 1950's as a consequence of the futile attempts to automatically translate from one natural language to another. The main result of the vast amounts of money, time and effort that these attempts consumed was the conclusion that much more research was needed to examine basic structures and operators of language (5).

Since that time, several theories of language have been developed, including theories of formal language, using the principles of propositional calculus, group theory and automata theory. These theories, although often readily susceptible to implementation,[2] deal primarily with restricted subsets of English or with "artifical" languages and are therefore not applicable to English on a broad scale. Other theories, which are descriptive in nature and are broadly applicable to natural language have not been easy to implement because of the complexity of the procedures or because of the large size of the vocabulary of a language. Grammars based on theories in this category include the transformational-generative (6), dependency (7), immediate constituent (8), phrase structure (9), predictive (10), systemic (11) and stratified (12) grammars of language. Versions of some of these grammars have been implemented, and have provided valuable empirical data. However, their implementation on a practical scale, (e.g., for use with a large data base of technical documents where the time to handle a single sentence is important) seems impossible. The severity of the time limitation suggested here can be seen in an attempt by Winograd to implement a theory of language. While his work in this area is extensive, and his results important, the system he has developed deals with an extremely limited universe of discourse (13), and its extension to some more extensive universe of discourse seems impractical.

---

[1] The frequent inappropriateness of this rule is illustrated by a statement attributed to Winston Churchill: "That is an imposition up with which I will not put!"

All of the theories mentioned here have unquestionably contributed to our understanding of language, but I believe they fail to account for the basic purpose of language and that they therefore fail to deal with the fundamental properties of language. In the next chapter, I propose a theoretical framework for studying the English language. I believe this theory makes it possible to operate on English utterances in algorithmic terms and that the results of these operations will be useful in developing automated indexing procedures.

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[2] Everywhere in this dissertation the word implement (and its derivatives) means "to render in a form suitable for processing by a digital computer."

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## CHAPTER II. A THEORETICAL FRAMEWORK FOR AN EMPIRICAL INVESTIGATION OF LANGUAGE

> I want to put the case clearly before you, and I will therefore show you what I mean by another familiar example. I will suppose that one of you, on coming down in the morning to the parlour of your house, finds that a tea-pot and some spoons which had been left in the room on the previous evening are gone,--the window is open, and you observe the mark of a dirty hand on the window-frame, and perhaps, in addition to that, you notice the impress of a hob-nailed shoe on the gravel outside. All these phenomena have struck your attention instantly, and before two seconds have passed you say, "Oh, somebody has broken open the window, entered the room, and run off with the spoons and the tea-pot!" That speech is out of your mouth in a moment. And you will probably add, "I know there has; I am quite sure of it!" You mean to say exactly what you know; but in reality you are giving expression to what is, in all essential particulars, an hypothesis. You do not *know* it at all; it is nothing but an hypothesis rapidly framed in your own mind. And it is an hypothesis founded on a long train of inductions and deductions.
>
> T. H. Huxley, *Darwiniana*

### 1. Introduction

A theoretical framework is essential to begin an experimental work. An hypothesis may be changed or discarded or new hypotheses may emerge in the course of an investigation, but only within a theoretical framework can experimental results assume general implications.

A theory rests upon observation and is verified through observation. Thus in any study of language one must gather evidence which may enable him to hypothesize about causes and effects. When we ask questions such as "What is the function of the preposition 'of' in English?" it is clear that we are already pretty far down a particular line of investigation having, apparently, observed such things as words, classified them (among other things) according to some scheme, and determined that at least some words have particular functions which it is our desire to determine.

While it is desirable that theories be as general as possible, it is rare that general theories emerge at early stages of an investigation. Rather theories are often devised for particular purposes and without any particular concern for generality. That is the case with the theoretical framework of English described in this Chapter. Prior to describing this theory, however, I feel it is necessary to make clear to the reader my views on the function and purpose of a theory. I attempt to do this in the following section. I hasten to point out that the remarks presented below are not to be construed as expressing any original thought on my part. On the contrary, these views are acknowledged to be the basis of scientific investigation (1). But scientists and laymen alike sometimes become so convinced of a theory, that the theory is accepted as a law. This acceptance has been the case in the treatment of the traditional model of grammar as an absolute. I therefore feel it is necessary to emphasize what Huxley has so admirably expressed in the quotation at the beginning of this Chapter concerning the nature of theory.

## 2. Function and Purpose of Theory

A theory is a way of representing, organizing and observing phenomena. It is a statement about the way in which one views and preceives phenomena (2). A theory is not purported to be an absolute. At one time, people held to the theory that the universe revolved around the earth. Ptolemy, based on this view of the universe, developed a system of epicycles to describe the movement of the universe. The mathematical formulations which he developed precisely described and predicted the movement of the planets. The theory is internally consistent and, even more impressive, experimentally verifiable. Now that man can look out from the stars, his view of the universe has changed and has necessitated different theories. But this does not destroy the consistency or precision of the earlier theory. And there is no guarantee, that at some future date, a new dimension will be added to the observables we now comprehend, and new theories of the behavior of the universe will emerge. This example illustrates that the structure set down by a theory and the relationships postulated among the objects with which it deals is not an attribute of the objects themselves. On the contrary, a theory imposes some form of logic or structure upon observables and provides for the interpretation of the observables within this framework (3).

For my purposes, a theory must not only be adequate in some abstract sense, it must also be useful. But how is utility to be measured? I can only say that for me a theory is useful so long as it helps toward the achievement of certain goals I have established for myself. Of course goals have a way of changing with time and thus so must theories. In effect, then, I judge a theory according to whether it serves me well in some investigation.

The main purpose of this chapter is to describe a theoretical framework for language which will serve for the analysis and description of language, at least of English, in terms that are considered beneficial in indexing, especially automatic indexing. This theoretical framework has permitted the expression of rules upon which algorithms[3] have been built to effect various analyses of English. These algorithms are described in Chapters III-V.

## 3. A Theoretical Framework for the Description and Analysis of Written English

### 3.1. Introduction

Language is a means of communication. But this sweeping statement is not particularly helpful. However, if one accepts English as a subset of language the subject matter to be dealt with is reduced to somewhat more manageable proportions, thereby excluding body language, chemistry, mathematics, and other languages from consideration. But English may be written or spoken and it seems that the properties of the two are sufficiently different that one may further reduce the subject matter by limiting one's attention to written English. In particular, the language dealt with in this research is that of technical and literary works.

### 3.2. The Basic Elements of Language

Whatever language is being considered, it seems to me that it may be described as a *system of things and relations between them*. In general, what are observed day by day are *things*[4]. Furthermore, these things exhibit changes with time. It is frequently found by observers to be useful or necessary to name the things and the changes they exhibit. For instance, when a rock is observed to fall from a cliff and when the observer wishes to communicate with someone about the changes the thing has undergone, the object may be called "rock" and the change in its location with respect to time "fall."[5] If one is near the terminus of the rock's path, one might say the rock "dropped," whereas if one is near the point from which it fell, one might say the rock "fell." The place from which the rock came (or departed) may also be named, for example, "cliff." The important thing to note here is that names are given to things and to behaviors exhibited by (or, if you will, attributed to) the things. (Any observable change of state, no matter how slight, I shall call a behavior). It is also importnat to note that a great effort is made to differentiate between the two types of names. Thus, I argue that language has as its basic elements names of things and names of behaviors. But there is a fundamental difference between the role and nature of names of things and of names of behaviors. Since things are often directly sensible and behaviors are never sensible, the former are treated as though they were related by means of the latter. In the example above, of the falling rock, the rock is directly sensible (by touch, smell, etc.) whereas "falling" is a name given to the change in

---

[3] An algorithm is a set of precise, unambiguous rules the application of which must produce results that are independent of the machine (or person) applying them (4).

[4] Simmons, *et al*. (5), use the term "concept" instead of thing, but I prefer "thing" as being potentially more general.

---

5. I may surely be forgiven for using the language I am attempting to describe. Subsequently, a word or phrase given special meaning within the context of this dissertation will be printed in upper case letters.

location of the rock with respect to time. That is, "falling" is the name given to the relation between the rock and its successive locations in space at successive points in time. I hope this illustration serves to clarify the notion of name-of-things, which I shall call, simply, NAME and of name-of-behavior, which I shall call RELATION.

Many researchers have in one way or another treated languages as relational systems. Rothstein has proposed the use of binary relations in representing strings of a language (6, 7). In a model of verbal understanding, Simmons (8) has defined primitive elements of his model to be *concepts* and *relations*; these primatives are essentially equivalent to my *thing* and *relation*. And as will be seen subsequently, the views of Montgomery (9), Fillmore (10), Chafe (11), and others are compatible with the relational nature of English I put forward here. I must note that the relations of which I speak are of two types: the one having some referent in actual experience, the other being exclusively a linguistic device. This matter is dicussed below in Section 3.3.2.

To summarize to this point, I have argued that a language consists of NAMES and RELATIONS. These names and relations are, in turn, strings of symbols formed from a basic set of symbols called an ALPHABET. Elementary alphabetical strings are called WORDs. A NAME is a word or string of words assigned to a thing, and a RELATION is a word or string of words assigned to a behavior. I have also said that a language provides for the production of more complex names or relations by combination of simpler names or relations. Let us now consider how this is done in English.

## 3.3 The Naming Process in Language

> "The name of the song is called 'Haddocks' Eyes'." "Oh, that's the name of the song, is it?" Alice said, trying to feel interested. "No, you don't understand," the Knight said, looking a little vexed. "That's what the name is called. The name really is 'The Aged Aged Man.'" "Then I ought to have said 'That's what the song is called'?" Alice corrected herself. "No, you oughtn't: that's quite another thing! The song is called 'Ways and Means': but that's only what it's called, you know!" "Well, what is the song, then?" said Alice, who was by this time completely bewildered. "I was coming to that," the Knight said. "The song really is 'A-sitting On A Gate': and the tune's my own invention."
>
> Lewis Caroll, Through the Looking Glass

While NAMEs and RELATIONs denote basic elements of a language, it will usually be found that simple NAMEs (single words) may be combined for naming many things or behaviors so that it is unnecessary to assign a unique name to every thing or behavior. In other words, the basic vocabulary[6] of a language will be found usually to be rather quickly extended to practical limits (of memory, essentially) and that to continue to name things and behaviors in a practical way, additional linguistic devices are required. For instance, there are many horses in the world and it would be cumbersome at best to have to assign a unique word, as a NAME, to each and every one, even though the language might provide the capability of doing so. Instead languages provide for the modification of basic NAMEs by permitting several NAMEs to be related to one another in special ways. A horse may be brown or black or large or fast or wild or docile. It may run or walk or trot or gallop and these terms my be specified as fast or slow or fluid or jerky or stylish. My point is that by providing appropriately for combining simple NAMEs to form more complex ones, a language becomes more powerful without the burden of a huge vocabulary. The relations between the NAMEs may be explicitly represented or not. For example, the relation between "brown" and "horse" in the NAME "brown horse" is established, in English, by the positioning of the words, whereas explicit relational words are often used as in "house of wax," where "of" serves this purpose.

---

[6] Recall the definition of vocabulary given in Chapter I.

### 3.3.1. Classification of NAMEs

A NAME may be simple, composite or complex. A SIMPLE NAME is a single word (string of alphabetical symbols exclusive of the blank) which is assigned to a thing. A COMPOSITE NAME is a consecutive sequence of SIMPLE NAMEs separated by one or more blanks. A COMPLEX NAME is an ordered triple, $N_1RN_2$, where $N_1, N_2$ are SIMPLE, COMPOSITE OR COMPLEX NAMEs, or are vacuous, and R is a RELATION. Examples of these three classes of NAME are given in Table 2.1.

In order to establish a relation between the NAME types defined here and traditional linguistic terminology, the reader may note that, from the example of Table 2.1, SIMPLE NAMEs seem to correspond with nouns, COMPOSITE NAMEs with a noun preceded by a series of adjectives, and a COMPLEX NAME with no traditionally defined entity. It is emphasized that no effort has so far been made to investigate the function of NAMEs in English, save that they represent things. Nor has any mention been made of possible methods for identifying them in English utterances. These matters are dealt with later.

Table 2.1 Examples of SIMPLE, COMPOSITE and COMPLEX NAMEs from English.

| SIMPLE | COMPOSITE | COMPLEX |
|---|---|---|
| horse | horse blanket | he is a man |
| trees | pine cone | a tree by the stream |
| rock | heavy black stone | rocks in his head |
| wind | cold front | the edge of a hurricane |
| water | running water | mountains shrouded in mist |
| ocean | white caps | |
| man | computer programs | Of Mice and Men |
| history | man's birth | |
| time | space/time continuum | |
| Mississippi | Missouri River | |

### 3.3.2. Classification of Relations

RELATIONs are of two kinds: primary and secondary. A PRIMARY RELATION is defined as a single word which is assigned to a behavior. PRIMARY RELATIONs are, in turn, of two types: dominant and recessive. A DOMINANT PRIMARY RELATION (DP-RELATION) is a PRIMARY RELATION which can serve in isolation to relate one or more names. A RECESSIVE PRIMARY RELATION (RP-RELATION) is a PRIMARY RELATION which serves as an argument of another PRIMARY RELATION. SECONDARY RELATIONs are defined as special linguistic elements which have no referents in experimental behaviors but serve only to relate NAMEs to NAMEs or to relate RELATIONs to NAMEs or to RELATIONs.

RELATIONs are also designated as simple or composite. A SIMPLE RELATION is a single PRIMARY or SECONDARY RELATION. A series of SECONDARY RELATIONs is a COMPOSITE SECONDARY RELATION (CS-RELATION). A series of DP-RELATIONs or a series of DP-RELATIONs followed by a SECONDARY RELATION is a COMPOSITE DOMINANT PRIMARY RELATION (CDP-RELATION). A series of RP-RELATIONs or a series of RP-RELATIONs followed by a SECONDARY RELATION is a COMPOSITE RECESSIVE PRIMARY RELATION (CRP-RELATION). An RP-RELATION in juxtaposition with a DP-RELATION cannot be subsumed within the DP-RELATION. Rather the RP-RELATION serves as a COMPLEX NAME or, as stated before, as an argument of the DP-RELATION .

This hierarchy of RELATIONs is shown in Figure 2.1. Relations have some connection with traditional linguistic terminology. PRIMARY RELATIONs correspond roughly with verbs, and SECONDARY RELATIONs with prepositions and conjunctions. RELATIONs in English are considered to

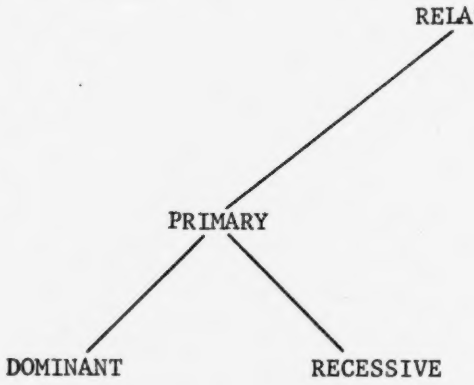
RELATION
PRIMARY
SECONDARY
DOMINANT
RECESSIVE

Figure 2.1 A hierarchical division of the types of RELATIONs.

function in the mathematical sense so that they take arguments just as do mathematical relations. It is important to note, too, that RELATIONs may connote various kinds of relationship between their arguments (such as equivalence, space/time, etc.). These connotations, though important in the broader aspects of linguistics, are not of interest in this work.

### 3.3.3. Definition of "Sentence"

From the foregoing definitions a SENTENCE can now be defined. A SENTENCE is an ordered triple $N_i R N_j$ where $N_i, N_j$ are NAMEs (SIMPLE, COMPOSITE, COMPLEX or vacuous) and where R is a PRIMARY RELATION (SIMPLE or COMPOSITE, never vacuous). If $N_i, N_j$ do not themselves contain PRIMARY RELATIONs, then this definition of "sentence" is equivalent to Cook's definition of "clause"[7] (12). I shall use Cook's definition of "clause ," so that "sentence" is superordinate to "clause ."

### 3.3.4. Interregnum

Let me give here an informal summary of the elements of the theory of language I am proposing. The basic elements of a language are things called symbols or alphabetical symbols. From these symbols, strings (linear sequences) of them may be formed which are called words. The set of such words is called a vocabulary. Some of these words name things and I have called these words NAMEs. Some words name behaviors of things, and I have called these words RELATIONs. More complex NAMEs and RELATIONs may be produced by stringing together simpler NAMEs and

---

[7] Cook states that a clause is a string of words with one and only one predicate (in my terms predicate = PRIMARY RELATION).

RELATIONs. A SENTENCE was defined as an ordered triple $N_i R N_j$ such that R is a PRIMARY RELATION. Given the special condition that the sentence contains but one PRIMARY RELATION, a CLAUSE was defined. In the next section I will show, for English, the way in which these various linguistic elements are employed, in order to complete the theory. The various terms so far defined are summarized in Table 2.2. A decomposition of a sentence based on the concepts presented is given in Figure 2.2.

### 3.4. Formal Statement of a Theory of Language

In Section 3.3 I have defined and exemplified certain notions basic to the theory of language I propose. The way in which these basic notions are interrelated in language utterances must now be specified in order to produce a coherent theory of language (at least of English). I shall first consider the function of RELATIONs and then shall define successively larger aggregates of NAMEs and RELATIONs culminating in the definition of SENTENCE.

#### 3.4.1. PRIMARY RELATIONs

In Section 3.3.2, RELATIONs were categorized as primary or secondary, simple or composite, dominant or recessive. The relationships between these categories of RELATION are illustrated in Figure 2.3. Some additional terminology is needed to facilitate further discussion of PRIMARY RELATIONs. COMPOSITE PRIMARY RELATIONs consist of a series of PRIMARY RELATIONs. Let us call the right-most RELATION a MAIN RELATION and the other RELATIONs in the series ALLIED RELATIONs. Thus, a PRIMARY RELATION may be characterized as

Table 2.2 Summary of Defined Terms.

| Term | Abbreviation | Definition |
|---|---|---|
| PRIMARY RELATION | | a single word which is assigned to a behavior. |
| SECONDARY RELATION | | a special linguistic element which has no referent in things or behaviors but serves to relate NAMEs to NAMEs or to relate RELATIONs to NAMEs or RELATIONs. |
| DOMINANT PRIMARY RELATION | DP-RELATION | a PRIMARY RELATION which can serve in isolation to relate one or more NAMEs. |
| RECESSIVE PRIMARY RELATION | RP-RELATION | a PRIMARY RELATION which is an argument of another PRIMARY RELATION. |
| SIMPLE RELATION | | a single PRIMARY or SECONDARY RELATION. |
| COMPOSITE SECONDARY RELATION | CS-RELATION | a series of SECONDARY RELATIONs |
| COMPOSITE PRIMARY RELATION | CP-RELATION | a series of PRIMARY RELATIONs |
| COMPOSITE DOMINANT PRIMARY RELATION | CDP-RELATION | a series of DP-RELATION or a series of DP-RELATIONs preceded or followed by a CS-RELATION. |
| COMPOSITE RECESSIVE PRIMARY RELATION | CRP-RELATION | a series of RP-RELATIONs or a series of RP-RELATIONs followed by a CS-RELATION |

Table 2.2 (continued)

| Term | Abbreviation | Definition |
|---|---|---|
| SIMPLE NAME | | a single NAME |
| COMPOSITE NAME | | a series of single NAMEs |
| COMPLEX NAME | | a NAME - RELATION - NAME triple |
| CLAUSE | | an ordered NAME - RELATION - NAME triple such that "RELATION" contains a PRIMARY RELATION and neither NAME contains a PRIMARY RELATION |
| SENTENCE | | an ordered NAME - RELATION - NAME triple such that "RELATION" contains a PRIMARY RELATION |

**SENTENCE:** The routine microscopic blood inspection that is a universal feature of present medical practice is generally depended on as one of the most useful indicators of the state of a person's health.

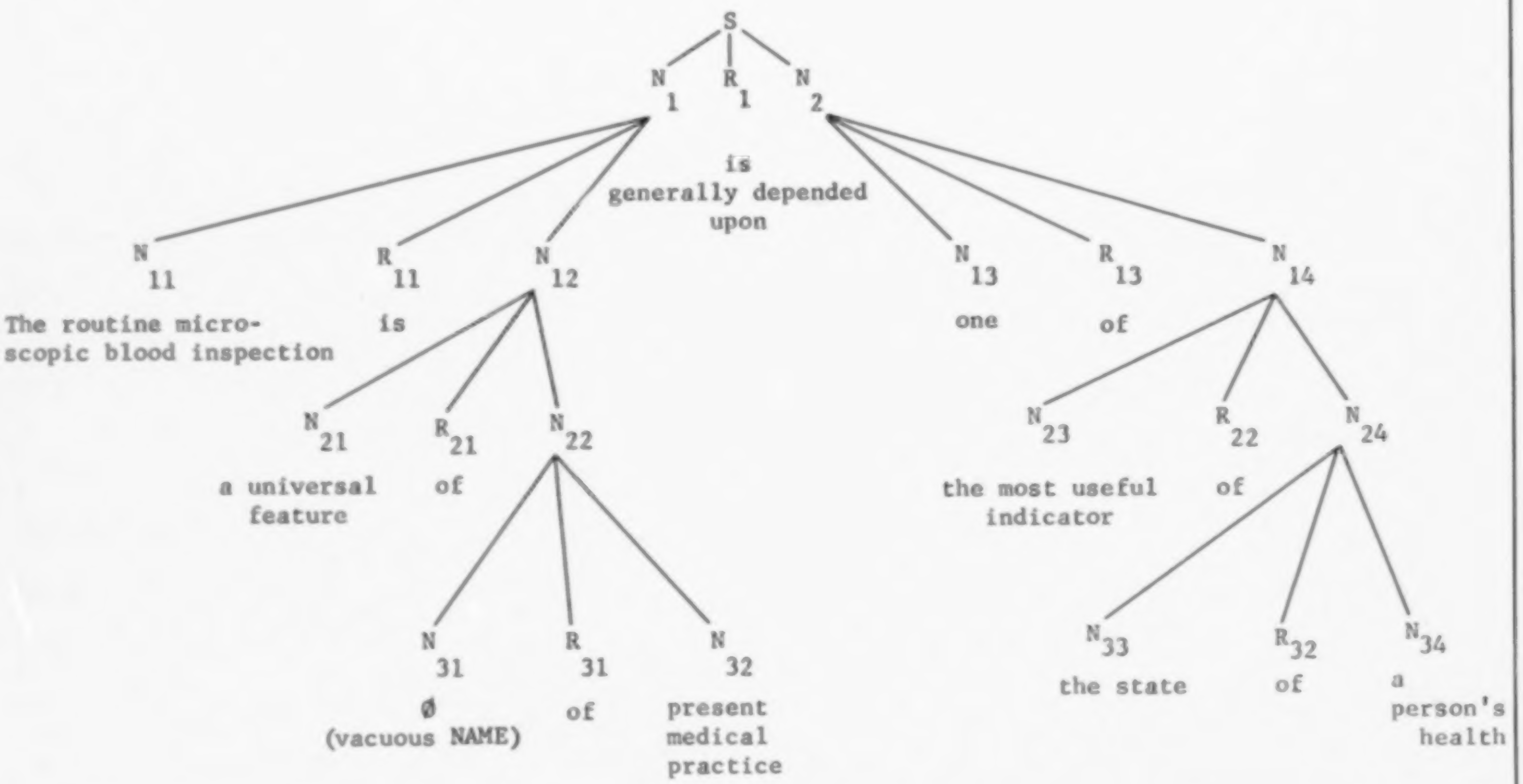
S
$N_1$
$R_1$
$N_2$
is generally depended upon
$N_{11}$
The routine microscopic blood inspection
$R_{11}$
is
$N_{12}$
$N_{13}$
one
$R_{13}$
of
$N_{14}$
$N_{21}$
a universal feature
$R_{21}$
of
$N_{22}$
$N_{23}$
the most useful indicator
$R_{22}$
of
$N_{24}$
$N_{31}$
Ø (vacuous NAME)
$R_{31}$
of
$N_{32}$
present medical practice
$N_{33}$
the state
$R_{32}$
of
$N_{34}$
a person's health

Figure 2.2 An example of a sentence analyzed in terms of NAMEs and RELATIONs. COMPOSITE NAMEs have not been decomposed.

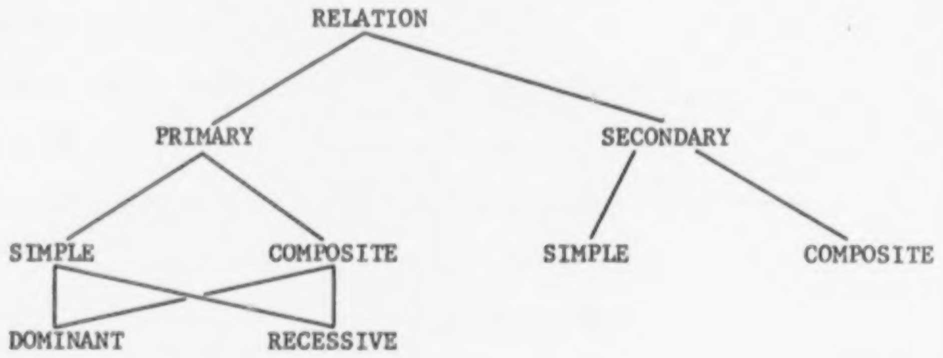
RELATION
PRIMARY
SECONDARY
SIMPLE
COMPOSITE
SIMPLE
COMPOSITE
DOMINANT
RECESSIVE

Figure 2.3 Relationships between categories of RELATION.

$$\text{(ALLIED RELATION)}_n \text{ MAIN RELATION} \qquad (n \geq 0)$$

If $n > 0$, then the string constitutes a COMPOSITE PRIMARY RELATION.

It will be convenient to further partition ALLIED RELATIONs into three classes: AUXILIARYs, MODALs and ADJUNCTs. These three classes are each ostensively defined as in Table 2.3. It can be seen that these three classes of ALLIED RELATION are quite similar to the traditional classes: auxiliary verbs, modal verbs and adjunct verbs.

MAIN RELATIONs may be either dominant or recessive (this distinction does not apply to ALLIED RELATIONs). The purpose of this distinction will be made clear shortly. RECESSIVE MAIN (RM) RELATIONs are of two types: PARTICIPIAL or INFINITIVAL. PARTICIPIAL RM-RELATIONs are SIMPLE RELATIONs ending in "ing," except for those mentioned in Table 2.4.[8] INFINITIVAL RM-RELATIONs are classed as marked or unmarked. Marked INFINITIVAL RM-RELATIONs are those RM-RELATIONs which immediately follow the SECONDARY RELATION "to." All other INFINITIVAL RM-RELATIONs are unmarked.[9]

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[8] The definition given of a PARTICIPIAL RM-RELATION must be distinguished from the traditionally accepted definition of participle. A PARTICIPIAL RM-RELATION is defined as the name of a behavior. Thus, the word "barking" in the phrase "the barking dog" is part of a COMPOSITE NAME, not a PARTICIPIAL RM-RELATION.

[9] As will be seen, this is not an adequate definition of unmarked INFINITIVAL RM-RELATIONs, for analytical purposes. No satisfactory general definition has so far been found.

Table 2.3 Classes of ALLIED RELATION and their Elements.[10]

| AUXILIARY | MODAL | ADJUNCT |
|---|---|---|
| am | can | did |
| are | could | do |
| be | may | does |
| been | might | keep |
| being | must | kept |
| is | shall | get |
| had | should | got |
| has | will | let |
| have | would | |
| having | | |
| was | | |
| were | | |

---

10. It is emphasized that the elements listed may also be found to be elements of the set of MAIN RELATIONs; the three classes are mutually exclusive only within the framework of ALLIED RELATION.

Table 2.4 RELATIONs ending in "ing" which are not PARTICIPIAL RM-RELATIONs.

bring
ding
fling
ring
sing
spring
cling
ping
bing
string
swing
wing

The complete hierarchy of PRIMARY RELATIONs is given in Figure 2.4.

### 3.4.2. SECONDARY RELATIONs

As stated earlier, SECONDARY RELATIONs are special linguistic devices which have no extralinguistic referents. However, SECONDARY RELATIONs play an important role in gaining an understanding of English. Therefore, it is necessary to make a number of subdivisions of SECONDARY RELATIONs. This is done in the following section. Some initial indication of the functionings of SECONDARY RELATIONs is also introduced at this time.

SECONDARY RELATIONs are initially divided into two classes: CONJUNCTIVE and ATTRIBUTIVE; these two classes are discussed, in turn, below.

### 3.4.2.1. The CONJUNCTIVE SECONDARY RELATIONs

CONJUNCTIVE SECONDARY RELATIONs (CSR) are categorized according to function. The categories are named COORDINATE, SUBORDINATE, ADVERBIAL, NOMINAL and ADJECTIVAL. Each of these categories is defined in the following paragraphs.

There are just five COORDINATE CSRs:

and
or
not
but
nor

SUBORDINATE CSRs are:

if
than
then
since
however
therefore
though
yet
although
thus
whether
unless

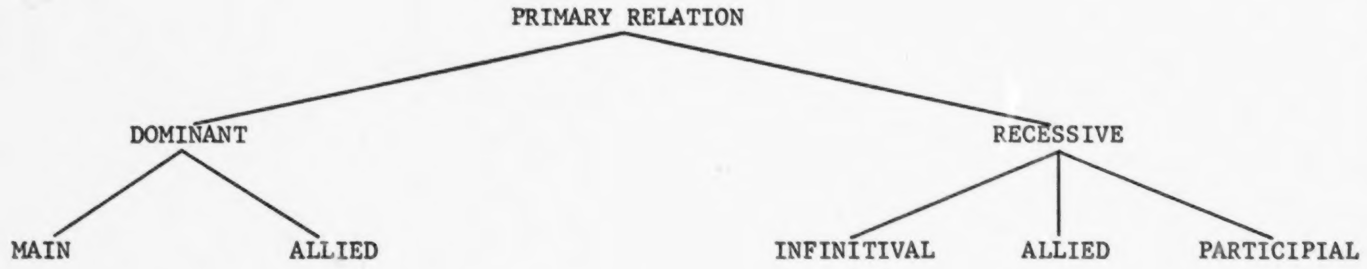
PRIMARY RELATION
DOMINANT
RECESSIVE
MAIN
ALLIED
INFINITIVAL
ALLIED
PARTICIPIAL

Figure 2.4 The complete hierarchy of PRIMARY RELATIONs.

Seven elements make up the set of ADVERBIAL CSRs:

where
where
in
from
by
for
to

The following words constitute the set of NOMINAL CSRs:

what
which
why
how
whoever
whomever
whatever
that
whom
of

Finally, the ADJECTIVAL CSRs are:

who
whom
where
when
that
whose
of

Obviously these classes of CONJUNCTIVE SECONDARY RELATIONs are neither mutually exclusive among themselves nor with respect to other classes of SECONDARY RELATIONs (see below). The means of distinguishing between the classes given a particular element will be dealt with in Section 3.4.3. First let me treat ATTRIBUTIVE SECONDARY RELATIONs.

### 3.4.2.2. The ATTRIBUTIVE SECONDARY RELATIONs

ATTRIBUTIVE SECONDARY RELATIONs (ASR) are listed below.

of
to
in
for
with
on
at
by
from
out
up
over
after
before
through
down
between
under
off
during
without
around
upon
until
toward
among
within
along
above
across
outside
except
beyond
inside
instead
throughout
despite
about
into
below
according
behind

ASRs serve either an ADJECTIVAL or an ADVERBIAL function. ADJECTIVAL ASRs are "of" and those ASRs which follow a DOMINANT RELATION and precede a SIMPLE or COMPOSITE NAME. All other ASRs are ADVERBIAL.

The hierarchy of SECONDARY RELATIONs is shown in Figure 2.5.

### 3.4.3. NAMEs

The concept NAME was defined in Section 3.3. It will be convenient to expand upon this concept both to provide additional useful terminology and to make clear certain functional distinctions between SECONDARY RELATIONs as alluded to above.

#### 3.4.3.1. The Notion of PHRASE

The term PHRASE will be applied as follows. A SIMPLE or COMPOSITE NAME will be called a NOMINAL PHRASE. Thus, any element in either of the first two columns of Table 2.1, for example, amounts to a NOMINAL PHRASE.

If either a SIMPLE or COMPOSITE NAME is immediately preceded by (*i.e.*, is an argument of) an ATTRIBUTIVE SECONDARY RELATION, and the RELATION/NAME NOMINAL is called a SECONDARY PHRASE.

A COMPOSITE PRIMARY RELATION is called a PRIMARY PHRASE.

A hierarchical arrangement of PHRASE types is shown in Figure 2.6. Examples of them are given in Table 2.5.

#### 3.4.3.2. The Notion of CLAUSE

A COMPLEX NAME containing one and only one PRIMARY RELATION is a PRIMARY COMPLEX NAME or *CLAUSE*. There are four basic types of CLAUSE: PRINCIPAL, NOMINAL, ADVERBIAL and ADJECTIVAL, related as illustrated in Figure 2.7.

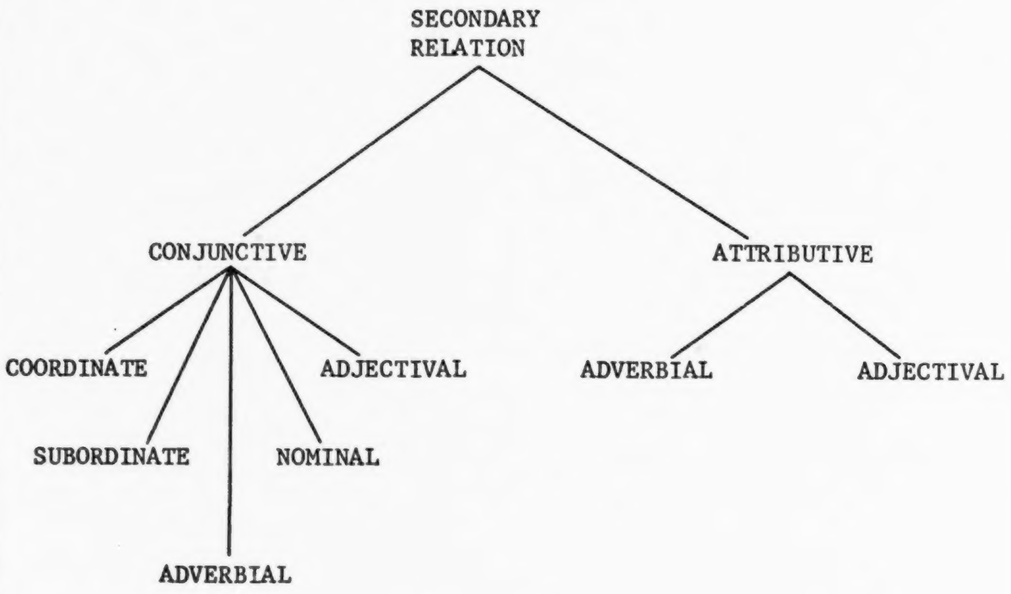
SECONDARY RELATION
CONJUNCTIVE
ATTRIBUTIVE
COORDINATE
SUBORDINATE
ADVERBIAL
NOMINAL
ADJECTIVAL
ADVERBIAL
ADJECTIVAL

Figure 2.5 Hierarchical partitioning of SECONDARY RELATION.

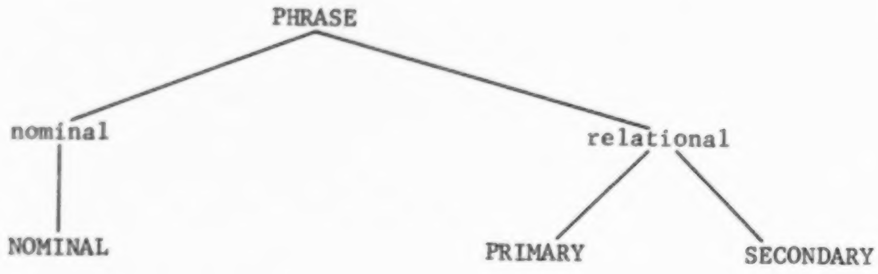
PHRASE
nominal
relational
NOMINAL
PRIMARY
SECONDARY

Figure 2.6 Partitioning of the class of PHRASEs.

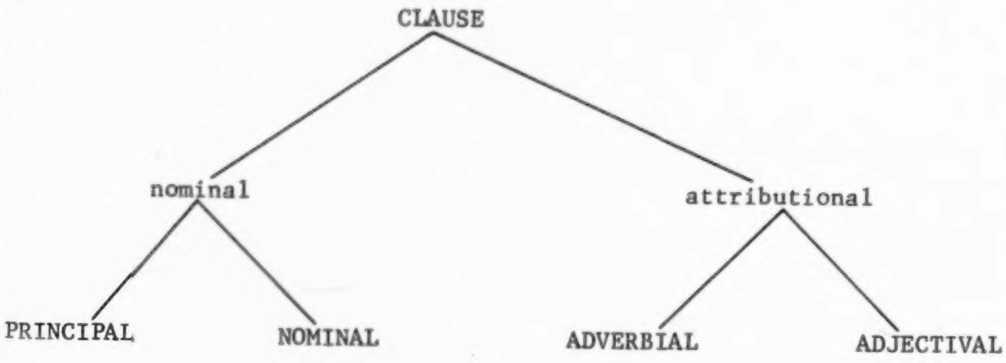
CLAUSE
nominal
attributional
PRINCIPAL
NOMINAL
ADVERBIAL
ADJECTIVAL

Figure 2.7 Partitioning of the class of CLAUSEs.

Table 2.5 Examples of NAMEs, PHRASEs and CLAUSEs

| Term | Illustrative Example |
|---|---|
| COMPLEX NAME | the book on the table |
| COMPOSITE NAME | the thick blue book |
| SIMPLE NAME | book |
| NOMINAL PHRASE | the thick blue book |
| PRIMARY PHRASE | has been gone |
| SECONDARY PHRASE | in the thick blue book |
| ADJECTIVAL CLAUSE | the girl sitting in the chair |
| ADVERBIAL CLAUSE | the birds flew where the weather was warm |
| NOMINAL CLAUSE | flying planes can be dangerous |
| PRINCIPAL CLAUSE | the musician became proficient by practicing every day. |

### 3.4.4. SENTENCE

Thus far, I have written at length about NAMEs and RELATIONs, and I have given some indication as to the way[11] these basic language elements are combined to form more complex units. But it still remains to consider the ways[11] in which these units are combined to produce the fundamental element of written English: the SENTENCE.[12]

Traditionally, a sentence has been thought of as a string of words expressing a complete thought (13). More recently, a sentence has been viewed as a string of words containing at least one predicate (14), or as any string of finite length composed of symbols from an alphabet (15). In this research, the simplest form of sentence has been the CLAUSE. If one considers that a RELATION demands a certain number of NAMEs as arguments and that these arguments may themselves contain other RELATIONs and their arguments, it is easy to see that English is a relational language after the notions of Rothstein (16).

I would like to think of SENTENCE as a NAME. Of course, SENTENCEs may be of varying complexities, ranging from just a single PRIMARY RELATION to strings containing many NAMEs and RELATIONs. But the problem is to specify the way in which relatively simple language units may be combined to yield SENTENCEs. From my point of view, it will suffice to show that, given a string of English words, rules can be devised within the framework of the theory of language I have so far presented that permit the identification of the linguistic units specified within the theory and that, as a consequence, permit one to say whether the given string is or is not an English sentence.

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[11] But not why they are so combined.

[12] Communication through written English does employ yet higher aggregations of linguistic units, but I shall not attempt to incorporate them into my theory of language at this time (see, however, Strong (17)).

Since, within the theoretical framework I have postulated, all types of relations have been identified and defined, I shall define SENTENCE quasi-ostensively through specification of the argument(s) each type of RELATION may take. The list of RELATIONs to be dealt with is given in Table 2.6, together with the range of arguments each may take. In order to express the RELATION/argument in a simple way I shall adapt Griswald's prefix notation (18) for my purposes. A few words are in order concerning this notation.

In prefix notation, the operator (relation) occurs first, followed by the arguments which it relates. Thus, the expression A + B would become +AB. The number of arguments associated with an operator is specified by a numeral subscripted to the operator. Thus, the previous expression becomes $+_2AB$. To avoid ambiguity in the application of operators, a precedence is assigned to them (*i.e.*, they are given a priority for first application).

For my purposes, 15 operators are employed, corresponding to the RELATIONs already defined. Table 2.7 lists the operator symbols which I shall use, together with their precedence and the RELATION to which each symbol corresponds. Each sentence type defined within the theory I propose is given in Table 2.8 together with an example English

Table 2.6 Definition of Prefix-Notation Symbols as Used in the Specification of SENTENCEs.

| SYMBOL | NUMBER OF ARGUMENTS (n) | PRECEDENCE | USE |
|---|---|---|---|
| a | $0 \leq n \leq 3$ | 2 | MAIN PRIMARY RELATION |
| b | $0 \leq n \leq 3$ | 2 | AUX and VRB or AUX and MOD |
| c | $0 \leq n \leq 3$ | 2 | AJN and VRB |
| d | $0 \leq n < 3$ | 2 | AJN |
| e | $0 \leq n \leq 3$ | 2 | PTC |
| f | $0 \leq n \leq 3$ | 2 | INF |
| g | $0 \leq n \leq 3$ | 2 | AUX and INF or MOD and INF |
| h | $n = 2$ | 1 | ADJECTIVAL ATTRIBUTIVE SECONDARY (AJAS) RELATION |
| i | $n = 2$ | 3 | ADVERBIAL ATTRIBUTIVE SECONDARY (AVAS) RELATION |
| j | $n \geq 2$ | 4 | CCP |
| k | $n \geq 2$ | 1 | CCN |
| l | $n = 2$ | 4 | SCN |
| m | $n = 2$ | 3 | ADJECTIVAL CONJUNCTIVE SECONDARY (AJCS) RELATION |
| n | $n = 2$ | 3 | ADVERBIAL CONJUNCTIVE SECONDARY (ADCS) RELATION |
| 0 | $n = 0$ | 1 | NOMINAL CONJUNCTIVE SECONDARY (NCS) RELATION |
| 'VERB' |  | - | Any from of specific verb |
| 'word' |  | - | A specific lexical entry |
| N |  | - | An upper case letter represents a NAME |

Table 2.7 Specification of SENTENCEs.

| SENT-ENCE TYPE | RELA-TION TYPE | ARGU-MENTS | NOTATION FOR SENTENCE | ILLUSTRATIVE EXAMPLE |
|---|---|---|---|---|
| 1 | a | 0 | $a_0$ | $\underbrace{\text{Go.}}_{a}$ |
| 2 | b | 1 | $b_1A$ | $\underbrace{\text{The boy}}_{A}\ \underbrace{\text{is going}}_{b}.$ |
| 3 | a | 2 | $a_1A$ | $\underbrace{\text{Throw}}_{a}\ \underbrace{\text{the ball}}_{A}.$ |
| 4 | a | 2 | $a_2AB$ | $\underbrace{\text{The boy}}_{A}\ \underset{a_2}{\text{threw}}\ \underbrace{\text{the ball}}_{B}.$ |
| 5 | a | 2 | $a_2AB$ | $\underset{a_2}{\text{Give}}\ \underbrace{\text{the boy}}_{A}\ \underbrace{\text{the letter}}_{B}.$ |
| 6 | a | 2 | $a_2AB$ | $\underbrace{\text{Flying planes}}_{A}\ \underset{a_2}{\text{are}}\ \underset{B}{\text{dangerous}}.$[13] |

---

[13] The example has been inserted to show that what is traditionally defined to be a participle (contrary to the definition of PTC in this work) is treated as part of a COMPOSITE NAME.

Table 2.7 (continued)

| SENTENCE TYPE | RELATION TYPE | ARGUMENTS | NOTATION FOR SENTENCE | ILLUSTRATIVE EXAMPLE |
|---|---|---|---|---|
| 7 | a | 3 | $a_3ABC$ | $\underbrace{\text{The boy}}_{A}\ \underset{a_3}{\text{gave}}\ \underset{B}{\text{me}}\ \underbrace{\text{the letter}}_{C}.$ |
| 8 | a | 3 | $a_3ABC$ | $\underset{A}{\text{They}}\ \underset{a_3}{\text{named}}\ \underset{B}{\text{him}}\ \underset{C}{\text{president}}.$ |
| 9 | d | 1 | $d_1g_1B$ | $\underset{d_1}{\text{Let}}\ \underset{B}{\text{him}}\ \underset{g_1}{\text{go}}.$ |
| 10 | d | 2 | $d_2Ag_1B$ | $\underbrace{\text{The boy}}_{A}\ \underset{d_2}{\text{let}}\ \underset{B}{\text{him}}\ \underset{g_1}{\text{go}}.$ |
| 11 | d | 1 | $d_1g_1A$ | $\underset{d_1}{\text{Let}}\ \underset{g_1}{\text{go}}\ \text{of}\ \underset{A}{\text{him}}.$ |
| 12 | $d_2$ | 2 | $d_2Ai_2a_1BC$ | $\text{The}\ \underbrace{\text{teachers}}_{A}\ \underset{d_2}{\text{kept}}\ \text{the}\ \underbrace{\text{children}}_{B}\ \underset{a_1}{\text{working}}\ \underset{i_2}{\text{in}}\ \text{the}\ \underbrace{\text{classroom}}_{C}.$ |
| 13 | d | 1 | $d_1i_2a_1BC$ | $\underset{d_1}{\text{Keep}}\ \text{the}\ \underbrace{\text{children}}_{B}\ \underset{a_1}{\text{working}}\ \underset{i_2}{\text{in}}\ \text{the}\ \underbrace{\text{classroom}}_{C}.$ |

Table 2.7 (continued)

| SENTENCE TYPE | RELATION TYPE | ARGUMENTS | NOTATION FOR SENTENCE | ILLUSTRATIVE EXAMPLE |
|---|---|---|---|---|
| 14 | d | 1 | $d_1a_0$ | $\underbrace{\text{Keep}}_{d_1}\ \underbrace{\text{working}}_{a_0}.$ |
| 15 | e | 1 | $a_2h_2Ae_1BC$ | $\text{The}\ \underbrace{\text{process}}_{A}\ \underset{h_2}{\text{of}}\ \underset{e_1}{\text{making}}\ \underset{B}{\text{bricks}}\ \underset{a_2}{\text{requires}}\ \underbrace{\text{intense heat}}_{C}.$ |
| 16 | e | 1 | $a_2e_1AB$ | $\underset{e_1}{\text{Flying}}\ \underset{A}{\text{planes}}\ \underset{a_2}{\text{is}}\ \underset{B}{\text{dangerous}}.$ |
| 17 | e | 1 | $b_2Ae_1B$ | $\underbrace{\text{The women}}_{A}\ \underbrace{\text{were tired}}_{b_2}\ \underset{\emptyset}{\text{of}}\ \underset{e_1}{\text{making}}\ \underset{B}{\text{pastries}}.$ |
| 18 | f | 2 | $a_2Af_2BC$ | $\underset{A}{\text{He}}\ \underset{a_2}{\text{wanted}}\ \underset{B_1}{\text{him}}\ \underbrace{\text{to lift}}_{f_1}\ \underset{C}{\text{weights}}.$ |
| 19 | f | 1 | $a_2Af_1C$ | $\underset{A}{\text{He}}\ \underset{a_2}{\text{wanted}}\ \underbrace{\text{to lift}}_{f_1}\ \underset{C}{\text{weights}}.$ |
| 20 | f | 0 | $a_2Af_0$ | $\underset{A}{\text{He}}\ \underset{a_2}{\text{wanted}}\ \underbrace{\text{to leave}}_{f_0}.$ |

Table 2.7 (continued)

| SENT-ENCE TYPE | RELA-TION TYPE | ARGU-MENTS | NOTATION FOR SENTENCE | ILLUSTRATIVE EXAMPLE |
|---|---|---|---|---|
| 21 | f | 2 | $d_2Af_2BC$ | He let him lift weights.<br>A $d_2$ B $f_2$ C |
| 22 | f | 1 | $d_2Af_1B$ | He let him go.<br>A $d_2$ B $f_1$ |
| 23 | f | 0 | $d_2Af_0$ | He let go.<br>A $d_2$ $f_0$ |
| 24 | g | 0 | $a_2An_2g_0B$ | He wanted $\underbrace{\text{to be}}$ known as $\underbrace{\text{a great artist}}$.<br>A $a_2$ $g_0$ $n_2$ B |
| 25 | h | 2 | $a_2h_2ABC$ | $\underbrace{\text{The boy}}$ in $\underbrace{\text{the red shirt}}$ hit $\underbrace{\text{the target}}$.<br>A $h_2$ B $a_2$ C |
| 26 | h | 2 | $b_2Ah_2BC$ | $\underbrace{\text{The student}}$ $\underbrace{\text{was taught}}$ $\underbrace{\text{the history}}$ of $\underbrace{\text{famous artists}}$.<br>A $b_2$ B $h_2$ C |
| 27 | i | 2 | $i_2b_1AC$ | $\underbrace{\text{The papers}}$ $\underbrace{\text{were thrown}}$ into $\underbrace{\text{the waste basket}}$.<br>A $b_1$ $i_2$ C |

Table 2.7 (continued)

| SENTENCE TYPE | RELATION TYPE | ARGUMENTS | NOTATION FOR SENTENCE | ILLUSTRATIVE EXAMPLE |
|---|---|---|---|---|
| 28 | i | 2 | $i_2 i_2 a_1 ABC$ | $\underbrace{\text{The ball}}_{A}\ \underset{a_1}{\text{rolled}}\ \underset{i_2}{\text{into}}\ \underbrace{\text{the street}}_{B}\ \underset{i_2}{\text{under}}\ \underbrace{\text{the car}}_{C}.$ |
| 29 | j | 2 | $a_2 j_2 ABC$ | $\underset{A}{\text{Bob}}\ \underset{j_2}{\text{and}}\ \underset{B}{\text{Carol}}\ \underset{a_2}{\text{built}}\ \underbrace{\text{a house}}_{C}.$ |
| 30 | j | 2 | $i_2 j_2 a_1 a_1 AB$ | $\underbrace{\text{The little boy}}_{A}\ \underset{a_1}{\text{ran}}\ \underset{j_2}{\text{and}}\ \underset{a_1}{\text{skipped}}\ \underset{i_2}{\text{into}}\ \underbrace{\text{the house}}_{B}.$ |
| 31 | j | 3 | $a_2 Aj_3 BCD$ | $\text{The}\ \underbrace{\text{children}}_{A}\ \underset{a_2}{\text{liked}}\ \underset{B}{\text{cats}},\ \underset{C}{\text{dogs}}\ \underset{j_3}{\text{and}}\ \underset{D}{\text{gerbils}}.$ |
| 32 | j | 2 | $i_2 i_2 a_1 ABC$ | $\underbrace{\text{The girls}}_{A}\ \underset{a_1}{\text{ran}}\ \underset{i_2}{\text{out of}}\ \underbrace{\text{the house}}_{B}\ \underset{j_2}{\text{and}}\ \underset{i_2}{\text{into}}\ \underbrace{\text{the street}}_{C}.$[14] |

---

[14] When a CCP joins SECONDARY PHRASEs initiated by an AVAS-RELATION, the C P is omitted from the notation.

Table 2.7 (continued)

| SENTENCE TYPE | RELATION TYPE | ARGUMENTS | NOTATION FOR SENTENCE | ILLUSTRATIVE EXAMPLE |
|---|---|---|---|---|
| 33[15] | k | 2 | $k_2i_2a_1AC(A)i_2a_1B$ | $\underbrace{\text{The dogs}}_{A}\ \underset{a_1}{\text{raced}}\ \text{down}\ \underbrace{\text{the hill}}_{C}\ \underset{k_2}{\text{and}}\ \underset{a_1}{\text{jumped}}\ \underset{i_2}{\text{into}}\ \underbrace{\text{the water}}_{D}.$ |
| 34 | k | 2 | $k_2a_1Ai_2a_1BC$ | $\underbrace{\text{The little dog}}_{A}\ \underset{a_1}{\text{laughed}}\ \underset{k_2}{\text{and}}\ \underbrace{\text{the dish}}_{B}\ \underset{a_1}{\text{ran}}\ \text{away}\ \underset{i_2}{\text{with}}$ <br> $\underbrace{\text{the spoon}}_{C}.$ |
| 35[16] | 1 | 2 | $1_2a_1Ab_1B$ | $\underbrace{\text{The experiment}}_{A}\ \underset{a_1}{\text{failed}}\ \underset{1_2}{\text{because}}\ \underbrace{\text{the equipment}}_{B}\ \underset{b_1}{\text{was faulty}}.$ |
| 36 | 1 | 2 | $1_2a_1Ab_1B$ | $\underset{1_2}{\text{Because}}\ \underbrace{\text{the equipment}}_{B}\ \underbrace{\text{was faulty}}_{b_1}\ \underbrace{\text{the experiment}}_{A}\ \underset{a_1}{\text{failed}}.$ |

15. In this SENTENCE the case is illustratedwhere one argument must be repeated in the formalization. the second occurrence of the argument is represented by enclosing the symbol in parentheses--"(A)."

16. SENTENCEs 35 and 36 illustrate that the operation representing SCN RELATION is followed first by the PRINCIPAL CLAUSE and then by the CLAUSE initiated by the SCN.

Table 2.7 (continued)

| SENT-ENCE TYPE | RELA-TION TYPE | ARGU-MENTS | NOTATION FOR SENTENCE | ILLUSTRATIVE EXAMPLE |
|---|---|---|---|---|
| 37[17] | m | 2 | $a_2(m_2)Ai_2b_1BCD$ | $\underbrace{\text{The girl}}_{A}\ \underset{\underset{(m_2)}{B}}{\text{who}}\ \underbrace{\text{was sitting}}_{b_1}\ \underset{i_2}{\text{in}}\ \underbrace{\text{the first row}}_{C}\ \underset{a_2}{\text{won}}\ \underbrace{\text{the prize}}_{D}$ |
| 38 | n | 2 | $n_2a_1Aa_2AB$ | $\underset{A}{\text{They}}\ \underset{a_1}{\text{stopped}}\ \underset{n_2}{\text{when}}\ \underset{A}{\text{they}}\ \underset{a_2}{\text{saw}}\ \underbrace{\text{the smoke}}_{B}.$ |
| 39 | $\emptyset$ | - | $a_1Ab_2BC$ | $\underset{A}{\text{He}}\ \underset{a_1}{\text{knew}}\ \underset{\emptyset}{\text{that}}\ \underset{B}{\text{she}}\ \underbrace{\text{was telling}}_{B_2}\ \underbrace{\text{the truth}}_{C}.$ |

---

[17] The ADJECTIVE COORDINATE SECONDARY RELATION "$(m_2)$" is placed in parentheses because $REL_1$ serves both as a NAME and a RELATION.

sentence for illustration. The following discussion should clarify the definition of SENTENCEs in these terms. Consider the SENTENCE

$$\text{The } \underbrace{\text{equipment}}_{A} \; \underset{h_2}{\text{in}} \; \underbrace{\text{this room}}_{B} \; \underbrace{\text{is used}}_{b_1} \; \underset{n_2}{\text{for}} \; \underset{e_1}{\text{testing}} \; \underset{C}{\text{compounds}}.$$

Each SIMPLE or COMPOSITE NAME is represented as a unique upper-case letter.

The SENTENCE contains four RELATIONs: "$h_2$" is an AJAS-RELATION with 2 arguments, "$b_1$" is a DP-RELATION with 1 argument, "$n_2$" is an ADCS-RELATION with 2 arguments and "$e_1$" is a RP-RELATION. To formalize the SENTENCE, begin with the highest precedence operator, i.e., the AJAS-RELATION "in," which relates "A" and "B" to form the COMPLEX NAME "$h_2AB$." The operator applied next is the PRIMARY RELATION operator. Since there are two, simply apply the operators in a left-to-right manner. "The equipment is used" becomes the COMPLEX NAME "$b_1h_2AB$" and "testing compounds" becomes the COMPLEX NAME "$e_1C$." Finally, apply the ADCS-RELATION operator to obtain the COMPLEX NAME "$n_2b_1h_2ABe_1C$ ."

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# CHAPTER III. IDENTIFICATION OF SIMPLE NAMES AND RELATIONS

> People studying a foreign language always worry about vocabulary. They will stare incredulously at a teacher who tells them that vocabulary is not the most important part of learning a foreign language. Occasionally a student may understand why this is true, but only after he has laboriously looked up all the words in a passage and still finds that he can make no sense out of the assembled words.
>
> Ann Eljenholm Nichols, *English Syntax*

## 1. *Introduction*

In the preceding chapter a theoretical framework was developed within which language was viewed as a relational system. Thus, two classes of linguistic element were demanded: NAMEs and RELATIONs. In this and succeeding chapters I shall attempt to show the usefulness of this theory as a guide in developing algorithms which identify and label various components of an English text. In this chapter, an algorithm is described which classifies words into several classes of NAME or RELATION according to the structural properties of the (usually) sentence examined. Before describing the algorithm, however, a review of some related work is presented in order to provide some context within which to view the present research.

## 2. *Overview of Related Work in Syntactic Analysis*

Syntactic analysis has been studied by many groups of researchers. In this section are reviewed those studies in syntactic analysis most pertinent to the present work. The section is divided into two parts.

The first part contains descriptions of four computer programs for syntactic analysis which, although rather large and complex, are well-grounded theoretically. In the second part are described six programs which bear especially close similarity to the program developed in this research.

Only superficial comparisons among these programs can be made. Each program has been developed to identify a unique set of grammatical classes; each has been designed based on a unique set of objectives; each has been implemented using a different programming language, and on a different computer. Furthermore, the accuracy of the results produced by these programs is not always available. Thus, these brief summaries are written to give the reader an idea of what has been accomplished and of the obstacles which remain to the improvement of algorithms for syntactic analysis.

## 2.1. Review of Syntactic Analysis Procedures--Part I

The four studies presented in this section give the reader a general overview of much of the research into syntactic analysis carried out to date. The procedures developed in each of the four projects have the common attribute of being quite large and complex. In each procedure a large lexicon (dictionary) is employed, and it will be seen that the procedures were developed without any attempt at a distinction between structural properties of a language and the intensional properties of the language. The nature of the procedures also necessitates that the lexicon be exhaustive. And in general, these procedures produce all possible analyses of a sentence from which one or more preferred ones may be selected, often manually.

All of the programs assign words to syntactic classes, but because of the nature of the grammar upon which the programs are based, word-class assignment is inextricably linked to phrase-group and clause-group assignment. For this reason, some of these programs will be mentioned again briefly in the succeeding chapter in which clause and phrase analysis is discussed. The investigations discussed in this section are those headed by Kuno and Oettinger, Zwicky, Sager, and Winograd.

### 2.1.1. The Multiple-Path Syntactic Analyzer

A well-known program for syntactic analysis is the Multiple-Path Syntactic Analyzer developed by Kuno and Oettinger (1). This system is based on a context-free grammar of 3400 rules and a top-to-bottom (top-down) analytical procedure employing a pushdown store. The dictionary used by this procedure gives a highly refined division of syntactic classes. For example, "are" belongs to three syntactic classes: one when used as an intransitive verb, one when used as a finite copula and one when used as an auxiliary to another verb. Each possible analysis of the sentence is explored in a left-to-right manner and verified or invalidated by the context-free grammar. The production of multiple analyses is useful for research purposes, but it is a decided disadvantage in practical application. Processing time is not directly dependent upon the length of a sentence but depends primarily on the number of possible surface structures which the sentence can generate (2). As an example, one 35-word sentence was reported to require 12 minutes for analysis (3).

### 2.1.2. Syntactic Analysis for Transformational Grammar

Zwicky (4) has included syntactic analysis in an attempt to implement a transformational grammar for sentences. The first phase of the program is a phrase-structure grammar, which, at present, handles a subset (32 rules out of a possible 134 rules have been implemented) of English. The initial step in Zwicky's procedure consists of a dictionary look-up of each word in a sentence. The dictionary contains all possible syntactic classes for a word, along with attributes such as tense, transivity, and number. This lexical entry also represents an entry in terms of more abstract elements, for example, "none" is defined as "neg any." After all possible syntactic classes for a word in a sentence have been retrieved, all possible analyses of a sentence are examined. The sentence

Can the airplane fly.

has 15 possible surface structures, since "can" has 5 entries, airplane has 1 entry and fly has 3 entries. In the next step a context-free grammar is applied to each of these analyses, and some structures are eliminated. Transformational rules are applied next in an effort to eliminate the spurious surface structures. The grammar is capable of analyzing sentences with more than one embedded clause. No discussion of the lexicon and of the rules used in both the context-free grammar and the transformational grammar is given. Although the process is only partially implemented,[18] Zwicky concludes that highly efficient routines are needed to obtain the correct surface structures (6).

### 2.1.3. Syntactic Analysis Based on String Analysis

In a project headed by Naomi Sager a string analysis grammar (7) is the basis of a syntactic analysis program. In this analysis, a sentence is viewed as a set of elementary strings (clauses). Modifiers and prepositional phrases are defined as adjuncts. Thus, the sentence

Cars without brakes cause accidents.

is described by the elementary string - N tV N (*i.e.*, noun, tensed verb, noun) and an adjunction class P N (preposition, noun). Rules are developed for the analysis of relative clauses and of clauses joined by coordinate conjunctions. The program utilizes a dictionary which identifies all possible syntactic classes of each word. In the first step of the program, the possible syntactic classes of each word in the sentence are retrieved. The assignments made during this step are:

```
Cars without brakes cause accidents.
 N      P     N/tV  N/tV/V    N
```

In the next phase of the program, the syntactic categories are examined in a left-to-right manner, while the grammar rules for elementary strings and adjuncts are matched to the possible analyses of the sentence. If a grammar rule fails to match up correctly with the sentence, the program backs up to the initial word of an adjunct or string and attempts to apply a different rule. Sager estimates that an adequate grammar for English could be accomplished with about 150 rules, plus another 150 restrictions. These restrictions analyze elements of the elementary string and check for such things as subject-verb agreement and well-formedness. No discussion is given of the timings, storage, the accuracy of the program or of the rules which have been developed (8).

---

[18] The lexical look-up and context-free parsing steps have not been programmed (5).

### 2.1.4. Syntactic Analysis for the Simulation of Natural Language Processes

Winograd has recently published a system design to explore how humans process language (9). The system includes procedures for both syntactic and semantic analysis. The syntactic analysis procedures are based on a systemic theory of grammar (10, 11). Although the theories of this grammar have not been stated in a unified way, the emphasis of this grammar is on the "informational units" (12) of a language. Winograd interprets these "informational units" as amounting to clauses and phrases.

In his procedures for syntactic analysis, Winograd has defined 18 word classes, 4 group types (noun, verb, adjective and preposition) and 2 clause types. The 18 word classes are a finer division of the traditional word classes. The two types of clauses are denoted as major and secondary. A major clause is either imperative, declarative or a question. Associated with each of these units is a set of attributes. Every unit belonging to a word class, group or clause is assigned a subset of these attributes. For example, a verb (*e.g.*, "began") may have the attributes "past," "infinitive;" a preposition group (*e.g.*, "in the kitchen") may have the attribute "locational object"; and a clause may have attributes such as "transitive," "passive" and "causality."

The components of the syntactic analysis process are a dictionary, a context-free grammar and a push-down list (PDL). The dictionary contains the vocabulary of the language, along with each entry's syntactic class and attributes. The program which implements the context-free grammar contains several functions which give the grammar context-sensitive aspects. As an example, one function checks for agreement between subject and predicate. A bottom-up parser is used to apply the context-free grammar.

This process appears to represent a viable system for the context in which it is used. While the universe of discourse for the system is small, Winograd has succeeded in developing a system which has the ability to synthesize sentences and which serves as an interesting tool in the investigation of question-answering systems (13).

## 2.2. Review of Syntactic Analysis Procedures--Part II

The investigations presented in this section require neither exhaustive dictionaries nor particularly complex procedures. Most of these programs have been based on ad hoc rules rather than on a well-developed theory of language. The studies presented here are those headed by Clark and Wall, Klein and Simmons, Stolz, et al., Thorne, et al., Resnikoff and Dolby, and Woods.

### 2.2.1. The Economical Parser

In this study a program was written which assigns words to grammatical classes, identifies phrase types and marks clause boundaries (14). The program first performs a dictionary look-up. The dictionary consists of about 1000 entries. The entries include function words, inflectional endings, and a list of words which are exceptions to regular inflection (*i.e.*, "thing" is not a verb even though it ends in "ing"). Words which are not found in the dictionary are assigned an ambiguous noun/verb category. In a second pass, phrase boundaries are tentatively identified. In the third pass clause boundaries are identified and clauses are tested for well-formedness. If a clause does not contain a verb, noun phrases are examined in a left-to-right manner and the first word which has been assigned to the noun/verb class is identified as a verb. Nine types of phrases and eight kinds of subordinate and relative clauses are identified. The algorithm was applied to abstracts of technical material and is reported to attain 91% accuracy in the identification of grammatical classes and 91% accuracy in the identification of phrases. The processing time is given as 24 words per minute. The algorithm was written in COBOL and executed on the IBM 7094 (15).

### 2.2.2. *The Computational Grammar Coder*

Klein and Simmons have implemented a Computational Grammar Coder (CGC) which assigns words in English text to the appropriate grammatical class. The CGC is the initial phase of a syntactic analyzer which is part of a question answering system. The CGC contains two types of dictionaries: 1) a function-word dictionary containing about 400 words, and 2) two dictionaries containing those nouns, verbs, and adjectives which are exceptions in various suffix texts. For example, while most words ending in "ing" are verbs, the word *swing* may be a noun. These dictionaries contained about 1,500 words.

The algorithm of the CGC begins by putting each word through a series of independent tests. These tests include a function word test, a capitalization test, a numeral test, and a series of suffix tests. Each test may result in the assignment of a set of codes to the word. If a particular test yields no information about a word, the system assumes that the classes noun, adjective, verb are possible. A final set of codes is obtained by taking the intersection of the set of codes assigned in each test.

After each word in a sentence has been identified in this manner, the context-frame test is made. This test sequentially processes strings of ambiguously coded words which are bounded by uniquely coded words. Every possible combination of codes of an ambiguously coded string is checked against a context-triad-frame table which contains permissible combinations of codes in such strings. When one of the sequences of codes of such a string is found in the context triad frame table, then this unambiguous sequence of codes is assigned. An example will clarify this process. Consider the sequence of codes:

| | | | |
|---|---|---|---|
| | adjective | noun | |
| article | verb | adjective | verb |

The first word of the string is an article, the second could be either an adjective or verb, the third either a noun or an adjective, the last is a verb. The following sequences of codes could be assigned to the ambiguously coded words:

| | |
|---|---|
| adjective | noun |
| adjective | adjective |
| verb | noun |
| verb | adjective |

The context-triad-frame table contains the following possible codes for two words which occur between an article and a verb:

| | |
|---|---|
| adjective | noun |
| noun | adverb |
| noun | noun |

The only sequence of codes common to the test string and to the table is ADJ - NON; thus, these are the codes which would be assigned.

This phase of the CGC is limited by two factors: 1) a string containing more than three ambiguously coded words cannot be handled and 2) out of 2,700 potential table entries, only 500 entries are included in the context-triad-frame table. The table entries were empirically derived by analyzing a chapter from the Encyclopedia Americana. The 500 entries included in the table accounted for 90% of the sequences of codes which were observed to occur in the test data (16).

The CGC, which was written in JOVIAL for an IBM 7090 uses just under 14,000 computer words. In tests using scientific text, the system correctly identified approximately 90%[19] of the words (17).

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[19] This figure refers to the correct identification of one of 30 classes: adjective, adverb, noun, verb, the verb to be, two classes of auxiliary verbs, articles, four classes of conjunctions, four classes of prepositions, and nine kinds of pronouns, punctuation, and verbs identified by inflectional endings.

### 2.2.3. The WISSYN System

The WISSYN system, designed to make grammatical class assignments to words in English text, was developed by Stolz, Tannenbaum and Carstensen (18). WISSYN contains dictionaries which are similar to those used in the CGC (Section 2.2.2.). The function-word dictionary contains about 300 words. If a word in a sentence is not found in the dictionary of function words, it is checked against a dictionary of suffixes. The word must also be checked against a list of about 60 words which are exceptions to the suffix tests.

A third phase attempts to resolve the ambiguity of certain function words. For example the word "that" may be used in the following ways:

that dog jumped
the dog that jumped

In this phase, a set of frames similar to those implemented by Klein and Simmons is used to resolve residual ambiguity.

A final phase of WISSYN uses the statistical frequencies of structural patterns of English sentences to assign grammatical classes. For this phase, probabilities of individual word classes occurring in a particular structural pattern were calculated by manually analyzing English text. The operation of this phase can be easily understood by considering an illustration. Given a sentence whose elements have been identified as:

$$T\ D\ N\ X_1\ P\ D\ N\ P\ X_2\ X_3\ T$$

where T is a terminal marker, D is a determiner, N is a noun, P is a pronoun, and $X_i$ is the ith unidentified word $(i \geq 1)$. When an unidentified word is encountered, the probabilities of all strings consisting of four or fewer words surrounding the unidentified word are considered. For the above example, the following strings would be considered:

T D N $X_1$ P

D N $X_1$ P D

N $X_1$ P D N

$X_1$ P D N P

T D N $X_1$

D N $X_1$

N $X_1$

$X_1$ P D N

$X_1$ P D

$X_1$ P

D N $X_1$ P D

Since the longest strings provide the most reliable probabilities, only the three longest strings are actually used. Thus, the probability of $X_1$ being a noun, verb, adjective, or adverb would be calculated by using the following statistics:

CONDITIONAL PROBABILITIES

| Predictor | NOUN | VERB | ADJ | ADV |
|---|---|---|---|---|
| T D N X | .046 | .819 | .013 | .122 |
| X P D N | .438 | .359 | .068 | .135 |
| D N X P N | .017 | .591 | .078 | .314 |
| JOINT PRODUCT | .00034 | .17377 | .00007 | .00517 |

The element $X_1$ would be designated as a verb, since this was the most probable case. The probability tables used include only the 150 most frequent predictor configurations. When a particular configuration is not found in the table, then the table is searched for the next longest string.

In a test of literary, scientific, and newspaper articles, an accuracy as high as 93% was attained.[20] WISSYN has been implemented on the CDC 1604 in CDC FORTRAN 60. The program, which is contained in approximately 6500 (48-bit) words of storage, can process about 2500 words per minute (19).

### 2.2.4. Syntactic Analysis Based on a Regular Grammar

Thorne, Bratley, and Dewar have written a syntactic analyzer as part of a system which assigns the deep structure and surface structure to English sentences (20). In this syntactic analyzer, 5 types of sentences, 6 types of clauses, and several other syntactic categories including, gerund subjects, active verbs, modifiers and indirect objects are identified.

The analyzer employes a dictionary of fewer than 200 words. It contains function words (referred to as closed-class words), verbs, suffixes and exceptions to these suffixes. The analyzer is based upon a form of transformational grammar. The operation of the system is as follows. First, all of the function words in a sentence are identified.

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[20] Words were classified according to the 14 categories: nouns, verbs, adjectives, adverbs, pronouns, determiners, linking verbs, auxiliaries, intensifiers, prepositions, relative pronouns, subordinators, connectors, negatives, preverbs, and exclamations.

Based on these function words and on the information provided by the grammar as it relates to the sentence, a set of predictions is made. These predictions are tested, and based upon the results of these tests, new predictions are made for successive parts of the sentence. All of the possible predictions are tested, and every prediction which holds produces a distinct analysis for the sentence.[21]

In some sentences none of the predictions which are made are satisfied. This happens when the sentence is improperly constructed or because the grammar is not complete. In this case, a program produces a message indicating that the analyzer has failed for this sentence.

This system was implemented on the KDF-9 computer. No figures were given for the amount of storage required by the program nor for the accuracy of the results which were obtained. While no average processing times were cited for the operation of the program, several examples of sentences which had been analyzed were given, along with the time needed to process them. The example which had the longest processing time (2.285 sec) contained 9 words, while the example which had the shortest processing time (0.427 sec) contained 1 word (21).

### 2.2.5. A Limited Program for Syntactic Analysis

Resnikoff and Dolby have written a program for grammatical class assignment which consists of fewer than 100 COMIT instructions (22).

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[21] Although these authors state that the grammar employed is a context-free grammar (CFG), these predictions effectively transform it into a context-sensitive grammar (CSG). This CSG appears to be similar to that developed by Kuno and Oettinger.

This program utilizes a dictionary of 200 function words and 200 affixes. At the time their paper was published, they intended to expand the dictionary to about 1000 words. In preliminary tests on texts which include parts of Ulysses by James Joyce and a New York Times editorial, the results were reported as being "evidently high"[22] (23).

### 2.2.6. Syntactic Analysis Based on Transition Network Grammars

Woods has developed a grammar described in terms of an augmented transition network. A recursive transition network is a directed graph with labelled states and arcs. The labels on the arcs may be state names or terminal symbols. An arc labelled with a state name produces the following action: the state at the end of the arc is stored in a pushdown stack and control passes to the state indicated by the arc. Control is passed back to the first state by popping the stack. This network is augmented by adding to each arc of the transition network an arbitrary condition which must be satisfied in order for the arc to be followed and a set of structure-building actions to be executed if the arc is followed. The algorithm accepts as input words of a sentence along with the grammatical class of each word of the sentence. The algorithm produces a labelled bracketing of the phrases of the sentence, an identification of the subject, object, verb and an assignment of the sentence type (*e.g.*, interrogative or declarative). The transition network model requires about the same (or more) processing time as predictive analyzers require.[23] The accuracy that the augmented transition network attains is not available (24).

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[22] In order to determine the correct grammatical class of a word, two criteria were used: first, the classification noun is used to signify both nouns and adjectives, and second, the correct classification must correspond to that given by either the Oxford Universal Dictionary or the Merriam-Webster Dictionary.

### 2.3. Summary

In the reviews presented above of research concerned with grammatical class assignment, two facts emerge. First, the more economically feasible approaches to grammatical class assignment have treated language as a relational system (at least implicitly). Second, the more successful approaches have avoided analytical procedures which depend upon large lexicons for much of their information.

The purpose of the work described in this chapter was to test the hypothesis that grammatical class assignment could be effected solely on the basis of a knowledge of the SECONDARY RELATIONs and certain PRIMARY RELATIONs contained in a sentence and of the absolute position of each word in the sentence and of the position of each word relative to the RELATIONs surrounding the word.

## 3. A Basis for Automated Syntactic Analysis

In the identification of NAMEs and RELATIONs, one must begin at the word level of analysis. If we suppose that an analytical procedure accepts as input a continuous string of English text, then as a first step, the individual words of that text must be identified. This identification requires a definition of WORD which I present in Section

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[23] Woods is apparently referring to the Multiple-Path Syntactic Analyzer of Oettinger and Kuno.

4.2. Once the individual words have been identified, the next step is to categorize them in some prescribed way. Traditionally, the categories have been the grammatical classes or parts of speech. Such categories have been used in this research, but it is important to observe that their definitions are different from the traditional ones. Before presenting these definitions, a brief review of earlier work in this regard is presented (Section 3.1.).

Upon categorization of the words in an English text, it is then possible to use a knowledge of these categories and of their sequential ordering in the text to produce larger aggregates (*i.e.*, either COMPOSITE or COMPLEX NAMEs).

The categorization of words is treated in this chapter. The aggregation of these categories into more complex units is dealt with in Chapter IV.

### 3.1. *Defining Grammatical Classes*

The words which comprise the vocabulary of a language are traditionally classified into eight parts of speech or grammatical classes. Dionysios Thrax is credited with first proposing eight parts of speech: noun, verb, participle, article, pronoun, preposition, adverb and conjunction (25). The interjection is often added to this list. For English, J. Priestly classified words into the above eight parts of speech in 1761 (26). Some parts of speech are given definitions based upon their *lexical meaning*. For instance, a noun is defined as the name of a person, place or thing. On the other hand, an adjective is defined as a word which modifies a noun. Such a definition is based upon *function*.

Gleason (27) has suggested an alternative method of defining grammatical classes. Three criteria are used as a definitional basis. The first criterion consists of a paradigm for each of the four classes: noun, verb, adjective and pronoun. Each paradigm consists of possible phonemic inflectional endings which signal membership in the appropriate class. The second criterion lists words whose membership in one of the four classes is signaled by a change in word form rather than by the addition of inflectional endings (*e.g.*, mouse and mice).[24] The third criterion is the syntax of the sentence in which a word occurs. This criterion, Gleason feels, is a less sure basis for word class identification than the first two. Gleason's approach to grammatical class assignment suffers because the definition of the classes is not sufficiently precise to serve as a basis for the development of algorithms and because it depends upon a subjective determination of a sentence.

Fries, in contrast with Gleason, has defined the parts of speech in terms of a basic structural frame or pattern (28). Each position within a structural frame is occupied by a particular word class. Any word which can fit into a given position in the frame belongs to the corresponding word class. For illustration, consider the sample frame sentences:

1. The concert was good (always).
2. The clerk remembered the tax (suddenly).

---

[24] These first two criteria have been developed into a computer-based stemming system (29).

3. The team went there.

A word which can replace either "concert," "clerk," "tax" or "team" belongs to Class 1. Words which can replace "was," "remembered" or "went" are members of Class 2. Any word which can replace "good" is placed in Class 3, and words which can replace "always," "suddenly" or "there" are placed in Class 4. These four classes roughly correspond to the traditional classes noun, verb, adjective and adverb. Fries chose not to use these terms because of the confusion that might result from definitional differences.

In addition to the four classes defined above, Fries defined a fifth class of words (Class 5) whose elements serve as structural markers within a sentence. These are frequently referred to as function words. They correspond in part to SECONDARY RELATIONs (Chapter II). The members of this class are most readily defined ostensively since there appear to be so few of them (Fries identified just 154). The class is divided into 15 groups which are distinguished by using the same structural criteria as are used for the first four classes. Some of the larger groups within this class are the auxiliary verbs, conjunctions, prepositions, relative pronouns and determiners.

There are significant differences between the first four classes and Class 5. For the first four classes, lexical meanings are easily separable from structural meanings. For function words (Class 5) no clear distinction can be made, perhaps because such words may have no lexical meanings. For instance, while one can detect differences in meaning among the prepositions at, by, for and from, clear distinctions cannot be made without reference to context.

Another important difference between the first four classes and Class 5 is that whereas the first four classes are open ended, Class 5 appears to be a closed class. As mentioned above, Fries identifies only 154 members of class 5, while there are many thousands of words in each of the other four classes. Furthermore, in an analysis of 1000 words of text, Fries found that function words accounted for almost a third of the total number of word occurrences. And in a more recent analysis of more than 1,000,000 words of text, Kucera and Francis have found that these words account for nearly 46% of the total number of words in the text studied (30).

Finally, it is easy to show that in order to understand certain structural signals within English text, Class 5 words must be known as items. For instance, the two sentences

The boys and the leaders were invited.

The boys of the leaders were invited.

may be analyzed to yield

Class-5 Class-1 Class-5 Class-5 Class-1 Class-5 Class-2

Class-5 Class-1 Class-5 Class-5 Class-1 Class-5 Class-2

The sentences are therefore indistinguishable on this basis. In fact, the only way in which a structural distinction may be made between the two sentences is to know the words *and* and *of* as items. In other words, the relationship between *boys* and *leaders* is established by the specific items *and* and *of*.

Another good example of the structural information provided by Class-5 words is found in the poem of the Jabberwocky:

Twas brillig, and the slithy toves
Did gyre and gimble in the wabe;
All mimsy were the borogoves,
And the mome raths outgrabe . . . .

Alice says that "Somehow, it seems to fill my head with ideas - only I don't exactly know what they are!"(31) The ideas which Alice derives from the poem are generated by the structural patterns and the underscored function words (32).

Function words also serve to eliminate ambiguity. Consider the sentence:

Ship sails today (33).

The ambiguity in this sentence can be avoided by adding function words or other structural markers. The above sentence could have any of the following meanings:

The ship sails today.
Ship the sails today.
Shipped sail today.
Ship sailed today.

The use of function words to resolve ambiguity has also been demonstrated by the work of Klein and Simmons in sentence generation (34). After incorporating function words in their program, lexical ambiguity was reduced by 90%. Beckman has also demonstrated that the use of function words in English serve the purpose of an error detecting code (35).

### 3.2. Formal Definition of Function Words

The work of Fries and others has demonstrated that a knowledge of function words and of the ways in which they operate within a sentence provides a concrete basis for the determination of grammatical classes. But to accomplish the development of an algorithm for grammatical class assignment, a rigorous definition of function words is required.

The definition provided by Fries (36), although structural in character, implies through use of the phrase "can replace" that human judgement is involved in determining class membership. Such a definition is unsuited for algorithm development. On the other hand, the definition can be made suitable by only slight modification: if the phrase "can replace" is replaced by "replaces" then we have a rigorous definition not only of the function words but of all the grammatical classes. There is, however, another disadvantage of Fries' definition that is not so easily overcome. By use of sample frames, grammatical class assignment becomes a process of pattern comparison. It has been shown (37, 38) that simple comparison techniques are unfruitful. The development of viable techniques therefore seems to depend upon a prior knowledge of sentence structure. Thus the use of sample frames leads to a circularity in processing at least when the processing is done algorithmically. As a consequence, I have endeavored to obtain definitions of the grammatical classes which do not depend upon reference to any data save that which is available directly from a sentence.

#### 3.2.1. Definition of Function Words

The class of FUNCTION WORDs is a set of words consisting of both

NAMEs and RELATIONs. FUNCTION WORDs are defined as comprising all SECONDARY RELATIONs; the AUXILIARYs, MODALs and ADJUNCTs; certain MAIN RELATIONs; and certain NAMEs. Each of the constituent subsets is defined ostensively, as follows.

SECONDARY RELATIONs were defined in Chapter II as consisting of 7 subclasses. Certain of these subclasses are now further subdivided. The complete hierarchy of SECONDARY RELATIONs is shown in Figure 3.1. The elements of each terminal class are listed in Table 3.1.

Among the PRIMARY RELATIONs, the class of ALLIED PRIMARY RELATIONs, consisting of the AUXILIARYs, MODALs and ADJUNCTs, is included in the FUNCTION WORD class. In addition, certain MAIN PRIMARY RELATIONs are treated as FUNCTION WORD elements. Table 3.2 contains the elements of PRIMARY RELATION which are members of FUNCTION WORD.

In order to specify what elements of the class NAME are members of FUNCTION WORD, it is necessary to subdivide NAME as shown in Figure 3.2. The elements of the terminal classes, which are listed in Table 3.3, are important structural markers in the identification of the principal classes NAME and RELATION.

Table 3.4 lists all the terminal classes which are included in FUNCTION WORD. The class of FUNCTION WORDs is thus completely defined and its relation to NAMEs and RELATIONs is demonstrated. Of course the subclasses of which FUNCTION WORD is comprised are not mutually exclusive, so that it is necessary to distinguish between them on structural grounds. A set of rules necessary for the complete and unambiguous determination of all word classifications is presented in the next section.

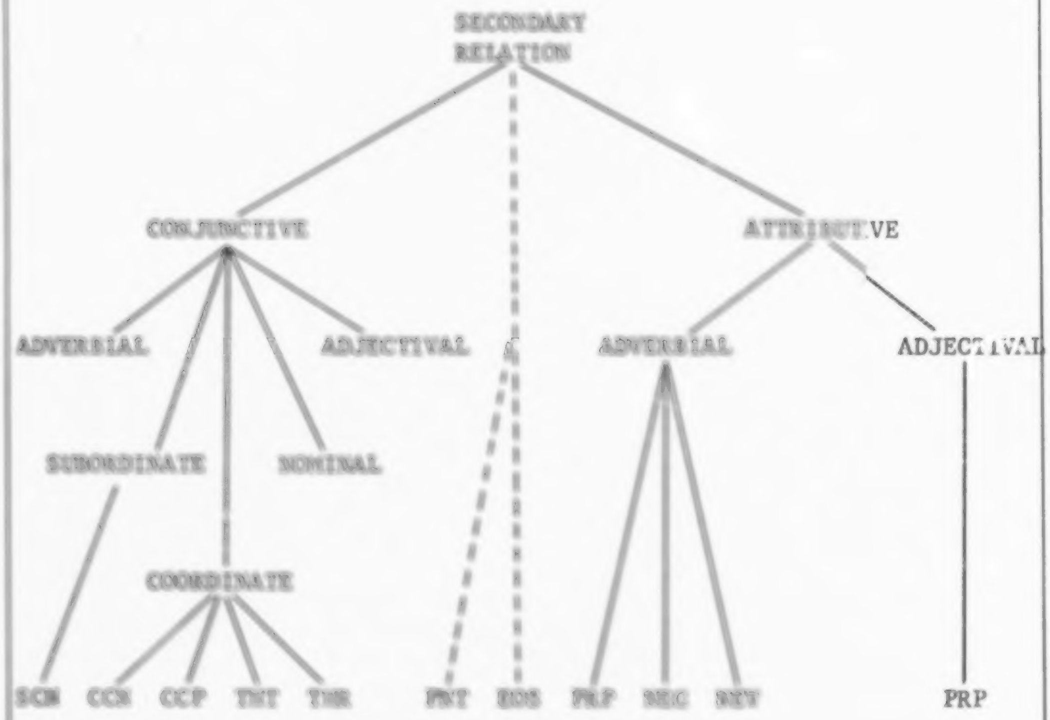
SECONDARY RELATION
CONJUNCTIVE
ATTRIBUTIVE
ADVERBIAL
ADJECTIVAL
ADVERBIAL
ADJECTIVAL
SUBORDINATE
NOMINAL
COORDINATE
SCN
CCN
CCP
TNT
THR
PNT
EOS
PRP
NEG
SET
PRP

Figure 3.1 Complete hierarchical division of SECONDARY RELATIONs. Definition of the terminal classes is given in Table 3.1.

Table 3.1 Specification of the Elements of each Terminal Class in SECONDARY RELATION.

| Class | Elements of the Class |
|---|---|
| CCN | and but nor not or |
| CCP | (same as CCN. Distinction made on structural basis. See Rule 71, page 90 ). |
| EOS | . ? ! |
| NEG | not |
| NEV | never |
| PNT | , ; : ' " ( ) |
| PRP | about above according across after along among around at before behind below between beyond by despite down during except for from in inside instead into of off on out outside over through throughout to toward under until up upon with within without |
| SCN | although however if since than then therefore though thus unless whether yet |
| THR | there |
| THT | that |
| ADJECTIVAL | These classes of CONJUNCTIVE SECONDARY RELATION are structurally defined (see Chapter III, Section 3.4.2.2) |
| ADVERBIAL | |
| NOMINAL | |

Table 3.2 Specification of the Elements of each Class of PRIMARY RELATION which are Elements of FUNCTION WORD.[25]

| Class | Elements of the Class |
|---|---|
| AJN | did do does get got let |
| AUX | am are be been being had has have having is was were |
| MOD | can cannot could may might must shall should will would |
| VRB | added appear appeared applied ask asked based became become becomes began believe born bring brought called carried closed come comes concerned consider considered continue continued covered decided described designed determine determined developed done dropped established expect find followed found gave give given gives go going gone happened hear heard held include increased indicated interested involved keep kept knew know known learned led limited lived look looked made make makes married meant meet met moved needed obtained opened paid passed placed played prepared provide provided put raised ran reach reached read received related remained remember reported required returned rise said sat saw say says see seem seemed seems seen sent serve set sewed showed shown speak spent started stress suggested take taken tell think told took tried turned understand walked want wanted went worked write written wrote |

---

[25] Contractions which contain function words (e.g., I'm) are PRIMARY RELATIONs, but such contractions are not listed here for the sake of simplicity.

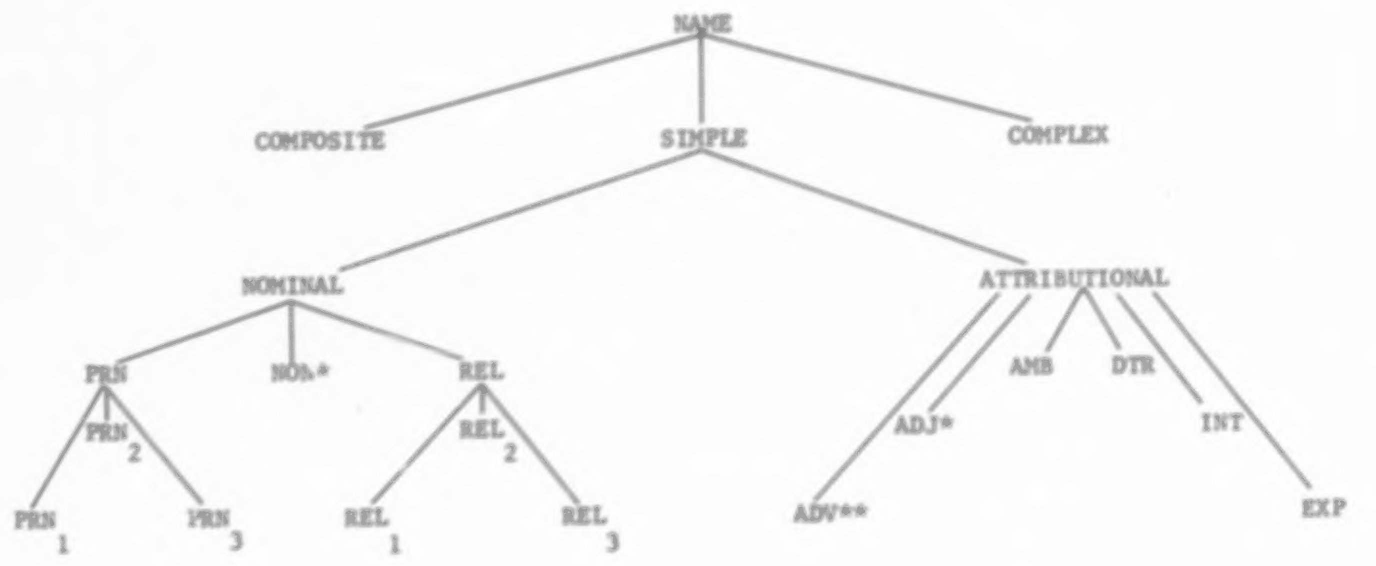
NAME
COMPOSITE
SIMPLE
COMPLEX
NOMINAL
ATTRIBUTIONAL
PRN
NOM*
REL
$PRN_2$
$REL_2$
$PRN_1$
$PRN_3$
$REL_1$
$REL_3$
AMB
DTR
ADJ*
INT
ADV**
EXP

Figure 3.2 Hierarchy of NAMEs showing particularly the terminal classes which are members of FUNCTION WORD. COMPLEX and COMPOSITE NAMEs are not members of FUNCTION WORD, nor are those classes marked with an asterisk (*). The double asterisk (**) signifies that those elements of ADV listed in TABLE 3.3 are members of FUNCTION WORD.

Table 3.3 Specification of the Elements of NAME which are Elements of FUNCTION WORD.

| Terminal Class | Elements of the Class |
|---|---|
| ADV | actually again ago ahead almost alone already always away apparently certainly clearly completely daily directly early easily especially even exactly farther finally forward further generally hardly here immediately just later less likely merely near nearly obviously often once only particularly perhaps probably ready really recently simply slowly sometime somewhat soon still suddenly today together too usually |
| AMB | all another both each eight either enough few five first four her hundred many million more most much neither one ones other own same second several six some ten these this those thru two whole |
| DTR | a an every his its my our the third your |
| EXP | oh well |
| INT | rather quite very |
| $PRN_1$ | anyone he him I it me none others she them they thing things us you |
| $PRN_2$ | anything everything nothing something |
| $PRN_3$ | herself himself itself myself themselves yourself |
| $REL_1$ | what whatever who whom |
| $REL_2$ | which whose |
| $REL_3$ | how when where while why |

Table 3.4 Composition of the Class of FUNCTION WORDs.

| MAJOR CLASS | TERMINAL CLASSES |
|---|---|
| NAME | ADJ ADV AMB DTR EXP INT NON<br>$PRN_1$ $PRN_2$ $PRN_3$ $REL_1$ $REL_2$ $REL_3$ |
| SECONDARY RELATION | CCN CCP EOS NEG NEV PNT<br>PRP SCN THR THR |
| PRIMARY RELATION | ADJ AUX MOD VRB |

### 3.2.2. Rules for Determination of Grammatical Classes

The FUNCTION WORDs together with the set of rules given below constitute necessary and sufficient conditions for the unambiguous determination of all grammatical classes present in an English sentence. The principal classes to be determined are the three subclasses of NAME: NON, ADJ and ADV; and the three subclasses of PRIMARY RELATION: VRB, INF (INFINITIVAL) and PTC (PARTICIPIAL). The rules to be described constitute a set of context sensitive productions which are most easily written by means of a simple notation. In addition to the names of the terminal classes given in Table 3.4, the symbols listed in Table 3.5 will be used. A simple example will serve to illustrate the use of the notation. Consider the rule:

$$\ldots \text{ THR XXX } \ldots \Rightarrow \ldots \text{ THR VRB } \ldots$$

and its interpretation: in a sentence, if the FUNCTION WORD subclass THR is immediately followed by an unclassified word, then that word is assigned to the class VRB.

#### 3.2.2.1. Rules for the Class DTR

Words in this class invariably initiate NOMINAL PHRASEs. However, the termination of a NOMINAL PHRASE is not so easily recognized. This problem is illustrated by the following example. Given the "sentence"

DTR XXX XXX PRP DTR DTR XXX EOS

one might be tempted to write a rule which would yield

DTR ADJ NON PRP DTR DTR NON EOS

The definition of SENTENCE given in Chapter II (p. 36 ) is, however, not satisfied, so that some sort of revision of the initial assignments is

Table 3.5 Definition of Notation Symbols used in the Rules for Grammatical Class Assignment.

| Symbol | Significance |
|---|---|
| XXX | any element of a sentence that has not been classified |
| ZZZ | any element of a sentence that has already been classified (*i.e.*, a generic class) |
| ¬ | logical *not* |
| \| | logical *or* |
| ⇒ | yields |
| ... | elements of unspecified type may be present |
| 'WORD' | any inflected form of the word enclosed in the quote marks |
| 'word' | precisely the word enclosed in the quote marks |
| XXX'ing' | an unclassified word ending in 'ing' |
| $XXX^n$ | element repeated n times |
| ( ) | used to enclose a series of alternatives |

necessary. In this instance it is possible to alter the assignments so that

DTR NON VRB PRP DTR DTR NON EOS

is obtained. I have taken precisely this approach in the present research. Rules involving the class DTR are designed to identify the start of a NOMINAL PHRASE, but they ignore the termination problem. Inaccuracies which this approach brings about are corrected in later stages of the analysis. The rules involving the class DTR are:

Rule 1:

... DTR XXX ... ⇒ ... DTR NON ...

Rule 2:

... DTR $XXX^n$ ... ⇒ ... DTR $ADJ^{n-1}$ NON ... $(n \geq 1)$

Rule 3:

... DTR (INT|ADV) $XXX^n$ ... ⇒
... DTR (INT|ADV) $ADJ^{n-1}$ NON $(n \geq 1)$

Rule 4:

... DTR XXX XXX'ing'ZZZ ... ⇒
... DTR NON PTC ZZZ ...

Rule 5:

... DTR $XXX^n$ XXX'ing'ZZZ .. ⇒
... DTR $ADJ^{n-1}$ NON PTC ZZZ ... $(n \geq 1)$

Rule 6:

... DTR VRB ... ⇒
... DTR ADJ ...

Rule 7:

... DTR ZZZ ... ⇒
... PRN ZZZ ...

### 3.2.2.2. Rules for the Class AMB

The class AMB consists of words which may belong either to the class DTR or to the class PRN depending upon context. Three simple rules serve to distinguish between the two classes.

Rule 8:

... AMB ZZZ ... ⇒ ... PRN ZZZ ...

Rule 9:

... AMB XXX ... ⇒ ... DTR XXX ...

Rule 10:

... (AMB|PRN) 'own' ... ⇒ ... PRN VRB ...

Note that the last rule also distinguishes 'own' as a member of VRB.

### 3.2.2.3. Rules for the Class PRN

The two subclasses of PRN, PRN$_1$ and PRN$_2$, are helpful in identifying the class VRB. Words in the class PRN$_3$ frequently are followed by the class ADJ. The following rules are based upon these classes.

Rule 11:

... PRN$_1$ XXX ... ⇒
... PRN$_1$ VRB ...

Rule 12:

$$\ldots\ \mathrm{XXX}\ (\mathrm{PRN}_1|\mathrm{PRN}_2)\ \ldots\ \Rightarrow\ \ldots\ \mathrm{VRB}\ (\mathrm{PRN}_1|\mathrm{PRN}_2)$$

Rule 13:

$$\ldots\ \mathrm{PRN}_2\ \mathrm{XXX}\ (\mathrm{AUX}|\mathrm{VRB})\ \ldots\ \Rightarrow\ \ldots\ \mathrm{PRN}_2\ \mathrm{ADJ}\ (\mathrm{AUX}|\mathrm{VRB})\ \ldots$$

Rule 14:

$$\ldots\ \mathrm{PRN}_2\ \mathrm{XXX}\ \mathrm{ZZZ}\ \ldots\ \Rightarrow\ \ldots\ \mathrm{PRN}_2\ \mathrm{VRB}\ \mathrm{ZZZ}\ \ldots$$

Rule 15:

$$\ldots\ \mathrm{PRN}_2\ \mathrm{XXX}\ \mathrm{XXX}\ \ldots\ \Rightarrow\ \ldots\ \mathrm{PRN}_2\ \mathrm{ADJ}\ \mathrm{VRB}\ \ldots$$

Rule 16:

$$\ldots\ \mathrm{PRN}_3\ \mathrm{XXX}\ \mathrm{XXX}\ \ldots\ \Rightarrow\ \ldots\ \mathrm{PRN}_3\ \mathrm{ADJ}\ \mathrm{VRB}\ \ldots$$

Rule 17:

$$\ldots\ \mathrm{PRN}_3\ \mathrm{XXX}\ \ldots\ \Rightarrow\ \ldots\ \mathrm{PRN}_3\ \mathrm{VRB}\ \ldots$$

### 3.2.2.4. Rules for the Class INT

The class INT gives rise to a single rule.

Rule 18:

$$\ldots\ \mathrm{INT}\ \mathrm{XXX}\ \ldots\ \Rightarrow\ \ldots\ \mathrm{INT}\ \mathrm{ADJ}\ \ldots$$

### 3.2.2.5. Rules for the Class REL

The class REL is divided into three subclasses, $\mathrm{REL}_1$, $\mathrm{REL}_2$ and $\mathrm{REL}_3$. The rules involving these classes are as follows.

Rule 19:

... 'which' (AMB|PRN|PRP) ... ⇒
... $REL_2$ (AMB|PRN|PRP) ...

Rule 20:

... $REL_1$ XXX ... ⇒
... $REL_1$ VRB ...

Rule 21:

... $REL_2$ $XXX^n$ ... ⇒
... $REL_2$ $ADJ^{n-1}$ NON ... $n \geq 1$

If EOS = ? then,

Rule 22:

... $REL_3$ XXX ... ⇒
... $REL_3$ VRB ...

otherwise,

Rule 23:

... $REL_3$ XXX'ing' ... ⇒
... $REL_3$ PTC ...

Rule 24:

... $REL_3$ XXX ... ⇒
... $REL_3$ NON ...

Rule 25:

... $REL_3$ XXX XXX ... ⇒
... $REL_3$ NON VRB ...

Rule 26:

$$\ldots\ \mathrm{REL}_3\ \mathrm{XXX}^n\ \ldots \Rightarrow \ldots\ \mathrm{REL}_3\ \mathrm{ADJ}^{n-2}\ \mathrm{NON\ VRB}\ \ldots \qquad n \geq 2$$

In general,

Rule 27:

... REL EOS ⇒ ... ADV EOS

### 3.2.2.6. The Class ADV

Words in this class cannot be reliably identified by any rules so far considered. For this reason, a list of words in the class ADV has been incorporated in the class FUNCTION WORD so that the rules which have been developed may prove to function more reliably. The words in this group are given in Table 3.3.

### 3.2.2.7. Rules for the Classes AJN, AUX and MOD

The elements of these classes are relatively few in number and the classes are reliable predictors of juxtaposed classes. Therefore a relatively large number of rules has been devised for these classes. The form of the rules differs in some instances depending upon the value of EOS. Rules involving the class AUX follow.

Rule 28:

... 'BE' (ADV|NEG|NEV) 'being' ⇒
... 'BE' (ADV|NEG|NEV) PTC ...

Rule 29:

... 'BE' 'being' ... ⇒
... 'BE' PTC ...

Rule 30:

... 'being' XXX ... ⇒
... (PTC|AUX) ADJ ...

Rule 31:

... 'being' $\mathrm{XXX}^{n}$ ... ⇒
...(PTC|AUX) $\mathrm{ADJ}^{n-1}$ NON $n > 1$

Rule 32:

... 'BE' (XXX'ing'|XXX'ed')... ⇒
... AUX VRB ...

Rule 33:

... 'BE' ADV (XXX'ing'|XXX'ed')... ⇒
... AUX ADV VRB ...

Rule 34:

... 'BE' XXX ... ⇒
...'BE' ADJ ...

Rule 35:

... 'BE' (INT|ADV) XXX ... ⇒
... AUX (INT|ADV) ADJ

Rule 36:

... 'BE' (INT|ADV) $\mathrm{XXX}^{n}$ ... ⇒
...'BE' (INT|ADV) $\mathrm{ADJ}^{n-1}$ NON $n \geq 1$

Rule 37:

... 'BE' $\mathrm{XXX}^{n}$ ... ⇒
... 'BE' $\mathrm{ADJ}^{n-1}$ NON ... $n \geq 1$

Rule 38:

... 'BE' 'having' ... ⇒
... AUX VRB ...

Rule 39:

... 'BE' (ADV|NEG|NEV) 'having' ... ⇒
... AUX (ADV|NEG|NEV) VRB

Rule 40:

... 'having' XXX'ed' ... ⇒
... PTC PTC

Rule 41:

... 'having' 'been' XXX'ed' ... ⇒
... PTC PTC PTC ...

Rule 42:

... 'having' ... ⇒
... PTC ...

Rule 43:

... 'HAVE' XXX'ed' ... ⇒
... 'HAVE' VRB

Rule 44:

... 'HAVE' XXX ... ⇒
... 'HAVE' NON ...

Rule 45:

... 'HAVE' $XXX^n$ ... ⇒ $n \geq 1$
... 'HAVE' $ADJ^{n-1}$ NON ...

If EOS = ?, then

Rule 46:

... AUX XXX (AUX|VRB) ... ⇒
... AUX NON (AUX|VRB)

Rule 47:

... AUX $XXX^n$ (AUX|VRB) ... ⇒
... AUX $ADJ^{n-1}$ NON (AUX|VRB) ...

Rule 48:

... AUX XXX ... ⇒
... AUX NON

Rule 49:

... AUX XXX XXX ... ⇒
... AUX NON VRB ...

Rule 50:

... AUX $XXX^n$ ... ⇒
... AUX $ADJ^{n-1}$ NON VRB $n \geq 2$

The following rules involve the class MOD.

Rule 51:

... MOD XXX ... ⇒
... MOD VRB ...

Rule 52:

... MOD ADV XXX ... ⇒
... MOD ADV VRB ...

Rule 53:

... (AUX| VRB) ... 'can' (DTR| PRP| PRN) ... ⇒
... (AUX| VRB) ... VRB (DTR| PRP| PRN) ...

Rule 54:

... (PRP|AUX|DTR) ('can'|'may'|'will') ... ⇒
... (PRP|AUX|DTR) NON ...

Rule 55:

... ('can'|'may'|'will') (PRP|DTR) ... ⇒
... NON (PRP|DTR) ...

The following rules involve the class AJN.

Rule 56:

... ('get'|'gets') (XXX'ing'|XXX'ed')... ⇒
... AUX VRB ...

Rule 57:

... ('keep'|'keeps'|'kept') XXX'ing' ... ⇒
... AUX VRB

Rule 58:

... ('let'|'lets') XXX ... ⇒
... AUX VRB ...

Rule 59:

... 'let' XXX PRP ... ⇒
... AUX VRB PRP

Rule 60:

... 'let' XXX XXX ... ⇒
... AUX NON VRB ...

Rule 61:

... 'let' $XXX^{n}$ ... ⇒
... 'let' $ADJ^{n-2}$ NON VRB $n > 2$

Rule 62:

... 'let' DTR XXX XXX ... ⇒
... 'let' DTR NON VRB ...

Rule 63:

... 'let' DTR $\text{XXX}^n$ ... ⇒
... 'let' DTR $\text{ADJ}^{n-2}$ NON VRB ... $n \geq 2$

Rule 64:

... 'let' PRN XXX ... ⇒
... 'let' PRN VRB

Rule 65:[26]

... ('did'|'does'|'do') NEG XXX ... ⇒
... ('did'|'does'|'do') NEG VRB ...

Rule 66:

... ('did'|'does') XXX ... ⇒
... AUX VRB ...

Rule 67:

... ('did'|'does') XXX XXX ... ⇒
... AUX VRB NON ...

Rule 68:

... ('did'|'does') $\text{XXX}^n$ ... ⇒
... ('did'|'does') VRB $\text{ADJ}^{n-2}$ NON ... $n \geq 2$

---

[26] The forms 'did' NEG, 'does' NEG and 'do' NEG are equivalent to 'didn't', 'doesn't' and 'don't', respectively.

Rule 69:

```
EOS 'DO' XXX ...  ⇒
                    EOS 'DO' VRB ...
```

### 3.2.2.8. The Class VRB

The PRIMARY RELATIONs are the most difficult to identify reliably. For this reason a number of the most commonly occuring members of this major class are included in the FUNCTION WORDs as the class VRB. The VRB class gives rise to no rules, but assists in the correct operation of other rules. The elements of VRB are listed in Table 3.2.

### 3.2.2.9. Rules for the Classes CCN, CCP and SCN

The elements of CCN and CCP are identical. Initially the elements which comprise these classes are identified as elements of CCN. The rules presented in this section identify the instances in which a word is an element of CCP. In later processing, the elements of CCN are used to identify clause boundaries. Some elements of SCN are also elements of VRB and PRP. The rules presented here identify these occurrences and reclassify the SCN element accordingly. The elements of CCN, CCP and SCN are listed in Table 3.1.

Rule 70:

```
... NON CCN (ME|HE|THEM|SHE|WE) ... ⇒
                                      ... NON CCN PRN
```

Rule 71:

```
... ADJ CCN XXX (EOS|PNT|CCN|SCN|THT) ... ⇒
                                      ... ADJ CCP ADJ ZZZ ...
```

Rule 72:

... ADJ CCN (ADV|INT) XXX (EOS|PNT|CCN|SCN|THT) ... ⇒
... ADJ CCP (ADV|INT) ADJ ...

Rule 73:

... (AUX|VRB) CCN XXX (DTR|PRN|PRP|EOS|PNT|CCN|SCN|THT) ... ⇒
... (AUX|VRB) CCP VRB ZZZ ...

Rule 74:

... NON CCN XXX (EOS|PNT|CCN|SCN|THT) ⇒
... NON CCP NON ZZZ ...

Rule 75:

... SCN XXX'ing' ... ⇒
... SCN PTC ...

Rule 76:

... SCN EOS ⇒
... ADV EOS

Rule 77:

... ('like'|'since') ... (AUX|VRB) ... (EOS|PNT|REL|CCN|SCN|THT) ... ⇒
... PRP ... (AUX|VRB) ... ZZZ

Rule 78:

... ('like'|'to') INF ... ⇒
... VRB PRP INF ...

### 3.2.2.10. Rules for the Class THR

The class THR while sometimes having the role of an ADV, generally initiates a clause and precedes the class VRB. If THR follows VRB or if it precedes a CONJUCTIVE SECONDARY RELATION, it is classified as ADV.

Rule 79:

... THR XXX ... ⇒
... THR VRB ...

Rule 80:

... (VRB|AUX) THR ... ⇒
... (AUX|VRB) ADV ...

Rule 81:

... THR PRP ... ⇒
... ADV PRP ...

### 3.2.2.11. Rules for the Class THT

The class contains the single element "that." The property which makes this element unique is that the element may belong to either the AMB class, the SCN class or the CONJUNCTIVE SECONDARY RELATIONs. Rules which apply to THT are similar to the AMB rules; however, THT is used in the later stages of MYRA (see Section 3.2.3.) to identify clause boundaries.

Rule 82:

... THT ZZZ ... ⇒ ... PRN ZZZ ...

Rule 83:

... THT XXX ... ⇒ ... DTR XXX ...

### 3.2.2.12. Rules for the Class PRP

Words in this class are used to identify NOMINAL PHRASEs, and elements of INF, and PTC. The elements of PRP are listed in Table 3.1.

Rule 84:

... 'to' XXX ... ⇒
... PRP INF ...

Rule 85:

... 'to' ADV XXX ... ⇒
... PRP ADV INF ...

Rule 86:

... 'to' $\text{XXX}^{n}$ ... ⇒
... PRN $\text{ADJ}^{n-1}$ NON $n \geq 1$

Rule 87:

... PRP XXX'ing' ... ⇒
... PRP PTC ...

Rule 88:

... PRP XXX XXX (AUX|VRB) ... ⇒
... PRP NON NON (AUX|VRB) ...

Rule 89:

... PRP $\text{XXX}^{n}$ (AUX|VRB) ... ⇒
... PRP $\text{ADJ}^{n-2}$ NON NON (AUX|VRB) ... $n \geq 2$

Rule 90:

... PRP XXX ... ⇒
... PRP NON ...

Rule 91:

... PRP $\text{XXX}^{n}$ ... ⇒
... PRP $\text{ADJ}^{n-1}$ NON $n \geq 1$

Rule 92:

... PRP (INT ADV) $XXX^{n}$ ... ⇒
... PRP (INT ADV) $ADJ^{n-1}$ NON $n \geq 1$

Rule 93:

... PRP (EOS PNT) ... ⇒
... ADV (EOS PNT) ...

Rule 94:

... XXX'ing' PRP ... ⇒
... PTC PRP ...

### 3.2.2.13. Rules for the Class NEV

This class is important because of its reliability in signalling the presence of a PRIMARY RELATION. NEV contains the single element "never."

Rule 95:

... NEV XXX ... ⇒
... NEV VRB ...

Rule 96:

... NEV ADV XXX ... ⇒
... NEV ADV VRB ...

Rule 97:

... NEV XXX'ing' ... ⇒
... NEV PTC ...

### 3.2.2.14. Rules for the Class NEG

NEG contains the single element "not." This element can be classed as either a CCN or as a component of a PRIMARY RELATION. The following rules differentiate these uses.

Rule 98:

... AUX NEG XXX ... ⇒
... AUX NEG VRB ...

Rule 99:

... MOD NEG XXX ... ⇒
... MOD NEG VRB ...

Rule 100:

... NEG XXX 'ing' ... ⇒
... NEG PTC ...

Rule 101:

... NEG ... ⇒
... CCN ...

### 3.2.3. Sufficiency of the Rules

In Section 3.2.2. it was stated that a knowledge of FUNCTION WORDs, together with the rules just described constitute necessary and sufficient conditions for the unambiguous determination of all grammatical classes as defined in this research. I believe these are necessary conditions: all elements of FUNCTION WORD are words that can reasonably be expected to occur in an English sentence and which serve the relational purpose defined for FUNCTION WORD; and the rules have all been established on the basis of patterns actually observed in English text (39). The question is therefore one of sufficiency.

It is not possible to say with certainty that FUNCTION WORD is complete, therefore it cannot be said to be sufficient on that basis. However, experimentation has shown (see Section 4) that for practical purposes it appears sufficient. Thus the question of sufficiency rests with the rules. Here it is easy to show that they are insufficient since a sentence that contains no element of FUNCTION WORD cannot be associated with any rule so far given. Furthermore, there is ample experimental evidence to show that even if this case were eliminated from consideration, there would yet be found structural patterns which the above rules do not account for. One must conclude therefore that the rules are insufficient. Can they be made sufficient? The answer to this question is a qualified "yes." The qualification is that the rules can be made sufficient in the sense that every element of every sentence can be classified. The question of accuracy of classification will be dealt with later.

Two types of rules need to be added to those already presented in order to complete the sufficiency condition. The first type is concerned with the classification of sentence elements which have not yet been classified. The second type deals with reclassification of previously classified elements so as to satisfy the definition of SENTENCE given earlier (Section 3.3.3.). These rules follow:

Rule 102:

$$\ldots \text{XXX}^n \ldots \Rightarrow \ \ldots \text{VRB} \ldots \qquad\qquad n = 1$$

Rule 103:

$$\ldots\ \text{XXX}^{n}\ \ldots\ \Rightarrow\ \ldots\ \text{NON VRB}\ \ldots \qquad n = 2$$

Rule 104:

$$\ldots\ \text{XXX}^{n}\ \ldots\ \Rightarrow\ \ldots\ \text{ADJ}^{n-2}\ \text{NON VRB}\ \ldots \qquad n > 2$$

Rule 105:

$$\begin{array}{ll} \ldots\ \text{XXX}^{n}\ \text{DTR ADJ}^{m}\ \text{NON ADJ}^{p}\ \text{NON}\ \ldots\ \Rightarrow & n = 0 \\ \quad \ldots\ \text{XXX}^{n}\ \text{DTR ADJ}^{m-1}\ \text{NON VRB ADJ}^{p}\ \text{NON}\ \ldots & m > 0 \\ & p \geq 0 \end{array}$$

Rule 106:

$$\begin{array}{ll} \ldots\ \text{XXX}^{n}\ \text{NON ADJ}^{p}\ \text{NON}\ \ldots\ \Rightarrow & n = 0 \\ \qquad\qquad \ldots\ \text{XXX}^{n}\ \text{VRB ADJ}^{p}\ \text{NON}\ \ldots & p > 1 \end{array}$$

Rule 107:

$$\begin{array}{ll} \ldots\ \text{XXX}^{n}\ \text{ADJ}^{m}\ \text{NON ADJ}^{p}\ \text{NON}\ \ldots\ \Rightarrow & n = 0 \\ \quad \ldots\ \text{XXX}^{n}\ \text{ADJ}^{m-1}\ \text{NON VRB ADJ}^{p}\ \text{NON}\ \ldots & m > 0 \\ & p \geq 0 \end{array}$$

If none of the above rules apply the following rules are applied in a left-to-right manner until a VRB assignment is made or until the end of the sentence is encountered.

Rule 108:

$$\ldots\ \text{DTR ADJ}^{n}\ \text{NON}\ \ldots\ \Rightarrow\ \ldots\ \text{DTR ADJ}^{n-1}\ \text{NON VRB}\ \ldots \qquad n > 0$$

Rule 109:

$$\ldots\ \text{ADJ}^{n}\ \text{NON}\ \ldots\ \Rightarrow\ \ldots\ \text{ADJ}^{n-1}\ \text{NON VRB}\ \ldots \qquad n \geq 0$$

Rule 110:

$$\ldots\ \text{NON}\ \ldots\ \Rightarrow\ \ldots\ \text{VRB}\ \ldots$$

## 4. MYRA - A Program for Grammatical Class Assignment

A program, called MYRA, has been developed which accepts English text as input and produces as output each word of text together with the name of the class to which it belongs. The class of FUNCTION WORDs and the rules described in Section 3 form the basis for the program.

MYRA is described in this section. Experimental results involving MYRA are given in Section 5.

### 4.1. General Description of MYRA

MYRA has been written in PL/I, and compiled using the F-level compiler of I.B.M. operating on an IBM System 370-165 (PHENIX XV, HASP II). MYRA is capable of processing text at a rate of 13,500 words of text per minute of C.P.U. usage. Approximately 126,000 bytes of storage are required for the program and working storage.

The heart of MYRA is a dictionary and a set of rules. Each of these is discussed in the following paragraphs.

### 4.1.1. The Dictionary

The class of FUNCTION WORDs defined in Section 3.2.1. is incorporated in a dictionary. The dictionary is ordered first by the length (number of characters) of its elements. If several elements have the same length, then each of these is ordered alphabetically. Such an ordering facilitates the dictionary look-up process (see Section 4.2.1., below). Associated with each element of the dictionary is a numerical code which identifies the class to which the element belongs and serves as a unique NAME for the element. These data are helpful in updating the dictionary. A program has been written to handle dictionary updates. It produces a dictionary acceptable to MYRA.

Two versions of the dictionary have been established for test purposes (see Section 5). One, the limited version, consists of all the terminal classes listed in Table 3.4, except ADV and VRB, and contains 217 elements. The second, called the extended dictionary, consists of all the terminal classes of Table 3.4. and contains 431 elements. The extended dictionary is included as Appendix A. The distribution of elements by length is shown in Figure 3.3.

### 4.1.2. The Rules

MYRA consists basically of a series of PL/I statements which correspond to the rules given in Section 3.2.2. The "execution" of these statements results in the classification of the words of a sentence.

## 4.2. Operation of MYRA

MYRA accepts English text as input in a continuous string without any prior formatting or marking. This fact has two implications. First, MYRA doesn't "know" that the input is English text, but the text will be processed as though it were. Second, MYRA must break the string up into individual words. A WORD is defined as any string of characters bounded by blanks, except that the elements of the classes PNT and EOS are isolated as individual words and labelled as members of the appropriate class. Hence, a string such as

becomes,

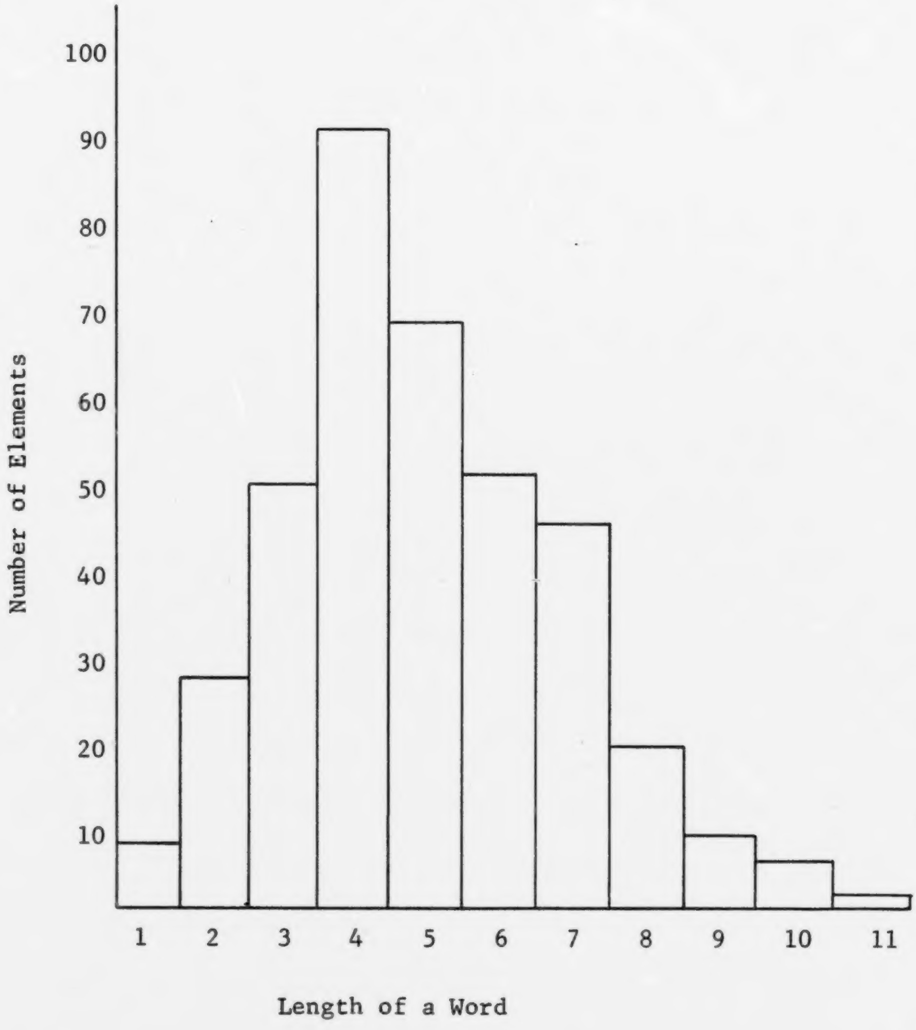

Figure 3.3 A bar graph of the number of elements of a given length in the extended dictionary.

is separated into two WORDs:

becomes

and

,

Once WORDs have been isolated, a preliminary SENTENCE boundary must be established. Any element of EOS serves this purpose. MYRA is then ready to effect grammatical class assignments.

MYRA operates on the input text, partitioned as outlined above, in three stages.

### 4.2.1. Dictionary Look-Up

In the first stage, the individual words, exclusive of those in PNT or EOS are looked up in the dictionary. The input word is matched only against those dictionary elements of the same length. If a match occurs, the code for the dictionary element is entered into a vector which corresponds with the sequence of words between elements of EOS. For instance, the input string

The mouse ate the cheese.

would have already been partitioned as

The/mouse/ate/the/cheese/.

and a corresponding vector

XXX XXX XXX XXX XXX EOS

set up.[27] If the first word of the string is looked up in the dictionary, a match will occur and the corresponding code retrieved. When all WORDs have been looked up (terminating with EOS), the program begins stage two. For our example, the vector resulting at the end of stage one will be

DTR XXX XXX DTR XXX EOS

### 4.2.2. Application of Rules 1-101

In the second stage, MYRA applies Rules 1-101. Application is signalled by the presence in the vector of an element of FUNCTION WORD or of some other element(s) already classified, so that only rules which can reasonably be expected to produce classifications are applied. In our example, we have at first a rule for DTR which can be applied (Rule 2). Its application yields

DTR ADJ NON DTR XXX EOS

Moving to the right in the vector, we see that a second rule for DTR is called for (Rule 1). Its application yields

DTR ADJ NON DTR NON EOS

Note that in stage two MYRA operates on the vector corresponding to the input string and does not process the input except in the instance of those rules that require a particular inflectional ending (*i.e.*, 'ing').

---

[27] I shall use the codes previously defined for illustration, rather than the numerical codes employed in MYRA.

At the end of stage two, the vector may or may not be complete. It is completed and verified in stage three.

### 4.2.3. Application of Rules 102-110

In stage three MYRA first classifies any previously unclassified WORDs. This is done by application of Rules 102-104. Finally, the vector is checked to see if a PRIMARY RELATION is present. (If the class AUX is not part of a COMPOSITE PRIMARY RELATION, AUX is reclassified as MAIN). If no PRIMARY RELATION is present, then Rules 105-110 are applied to reclassify elements of the vector so that a PRIMARY RELATION is included. The analysis is thus completed and the results are output. In our example, at the end of stage two the vector contained no PRIMARY RELATION. Application of Rule 108 causes the sequence

DTR ADJ NON ...

to be transformed to

DTR NON VRB ...

so that the final vector would be

DTR NON VRB DTR NON EOS

The application of MYRA to several English texts and the results obtained are described in the next section.

## 5. Experimental Testing of MYRA

In order to determine the efficacy of MYRA, three bodies of text, derived from

a) *The Need for More Precise Definition of "Algorithm"* by
B. A. Trakhtenbrot

b) *The Old Man and the Sea* by Ernest Hemingway

c) *The Clavichord and How to Play It* by M. Halford

and totaling about 6000 words were used. These texts were processed using both the limited and extended dictionaries (Section 4.1.1.). The results were then analyzed manually in order to determine the accuracy of the classifications. Wherever an error was found, its cause was identified (as far as possible). The accuracy of the classification was based upon my own intuitive knowledge of English. Hence, I set myself up as the standard against which the results of MYRA were evaluated. The results of this analysis are presented in Tables 3.6 and 3.7. Using the limited dictionary, MYRA produced results that were 91% accurate on average using the evaluation criterion mentioned above. With the extended dictionary, MYRA achieved an average accuracy of 94%. More detail concerning the evaluation of MYRA will be found in Appendix D. Sample output from MYRA is shown in Figure 3.4. Complete output for the second body of text (*The Old Man and the Sea*) is included as Appendix C.

Table 3.6 Error Analysis of the Results Produced by MYRA Using the Limited Dictionary.

| Text | Overall Accuracy | % of Errors by Type | | | | |
|---|---|---|---|---|---|---|
| | | NON | VRB | ADJ | ADV | OTHER |
| "...Precise Definition of 'Algorithm'" | 92% | 28% | 35% | 10% | 16% | 11% |
| The Old Man and the Sea | 90% | 26% | 33% | 14% | 12% | 15% |
| "The Clavichord..." | 92% | 25% | 28% | 21% | 16% | 10% |

Table 3.7 Error Analysis of the Results Produced by MYRA Using the Extended Dictionary.

| Text | Overall Accuracy | % of Errors by Type | | | | |
|---|---|---|---|---|---|---|
| | | NON | VRB | ADJ | ADV | OTHER |
| "...Precise Definition of 'Algorithm'" | 94% | 33% | 20% | 17% | 15% | 15% |
| The Old Man and the Sea | 95% | 33% | 27% | 24% | 9% | 7% |
| "The Clavichord..." | 94% | 21% | 22% | 29% | 15% | 13% |

```
The old man had taught the boy  to  fish and the boy loved him.
DTR ADJ NON AUX   VRB   DTR NON  PRP  VRB CNJ DTR NON  VRB PRN EOS
```

Figure 3.4 Sample output produced by MYRA from the text *The Old Man and the Sea*.

## 6. Summary

In Chapter II I have presented a theoretical framework suitable for the syntactic analysis of English text. Based upon this framework, a program, MYRA, has been developed implemented and tested which assigns words in a sentence to their appropriate grammatical classes (*i.e.*, identifies them as NAMEs or RELATIONs). The test results have been analyzed and an accuracy of identification of between 91% and 94% has been found. Thus, MYRA has been shown to have a theoretical base, to produce accurate results and to operate at a high rate of speed (at 13,500 words per minute).

The output of MYRA forms the input to procedures described in Chapter IV. Further conclusions which may be drawn from the results so far obtained in this research will be deferred until the last chapter of this dissertation.

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# CHAPTER IV. IDENTIFICATION OF COMPOSITE AND COMPLEX NAMES

> All the innumerable substances which occur on earth--shoes, ships, sealing-wax, cabbages, kings, carpenters, walruses, oysters, everything we can think of--can be analysed into their constituent atoms, either in this or in other ways. It might be thought that a quite incredible number of different kinds of atoms would emerge from the rich variety of substances we find on earth. Actually the number is quite small. The same atoms turn up again and again, and the great variety of substances we find on earth results, not from any great variety of atoms entering into their composition, but from the great variety of ways in which a few types of atoms can be combined--
>
> Sir James Jeans, The Universe Around Us

> There are countless ways of writing English sentences. ... But sentences in English have certain elements in common, and when you start to analyze these sentences, you will find that there are a very few basic sentence patterns that all writers use.
>
> Ann Eljenholm Nichols, English Syntax

## 1. Introduction

The preceding chapter has dealt with procedures for identifying SIMPLE NAMEs and RELATIONs, procedures which were based upon a knowledge of a special class of WORDs, called FUNCTION WORDs, and upon a set of rules involving structural patterns. In this chapter I build upon the previous results. Procedures are described whose purpose is the identification of COMPOSITE and COMPLEX NAMEs. These procedures are based upon the definition of COMPOSITE NAME and COMPLEX NAME given in Chapter II, and upon structural signals provided by elements of FUNCTION WORD and by the arrangement of SIMPLE NAMEs and SIMPLE RELATIONs within a sentence as identified by MYRA. Before describing these procedures, brief mention must be made of certain related research. In Chapter III, Section 2.1, several projects were reviewed in which either a form of top-down parser (1, 2, 3, 4) or of bottom-up parser (5) was used. The output of these parsers included grammatical class assignment, phrase-type recognition and clause identification. These parsers are similar to one another in that each employs a large dictionary which contains all possible grammatical classes for each lexical entry. The size of the dictionary and the complexity of the procedures result in long processing times. One possible exception to this statment may be afforded by the work of Woods (6). Although extant publications by Woods indicate processing times comparable to those realized for other top-down parsers, unconfirmed reports indicate that Woods has substantially decreased his processing times (7).

One of the projects reviewed in Chapter III not only involved the identification of word classes, but also the identification of nine phrase types (noun, prepositional, pronoun, infinitive, verb, adverbial, post-modifying adjective, present participle and past participle) (8). Stolz, Tannenbaum and Carstensen reported an accuracy of 91% in the application of their procedures to both technical and nontechnical abstracts (8). Clauses were also identified, but the details of clause identification were not given.

In general, previous work on phrase and clause identification has relied heavily on lexical information and it was therefore of interest to test the hypothesis that the desired results could be attained without recourse to extensive dictionaries and with rather minimal rules. A description of the results of such tests forms the remainder of this chapter.

## 2. Procedures for the Identification of CLAUSEs

In this section is described a prototype system for the identification of the class of COMPLEX NAMEs called CLAUSEs as they occur in English text. This system is one component of the language analysis system described in this dissertation. An improved version of this prototype is outlined in Section 4.

The set of procedures which identify CLAUSEs is called CAP/I (CLAUSE Analysis Procedures/I). Input to CAP/I is the output of MYRA (Chapter III). The delimitation of CLAUSEs by CAP/I is based primarily upon structural signals. These signals include the classes of CONJUNCTIVE SECONDARY RELATION, namely SCN, CCN, CCP, THT and THR, as well as the classes PNT, EOS, INF and PTC (see Table 3.1 for definition).

CAP/I operates in two phases. CLAUSEs are identified in either phase according to the structure of the SENTENCE which contains them and according to the type of CONJUNCTIVE SECONDARY RELATION (if present) that introduces the CLAUSE. The rules employed in each phase of CAP/I are described below.

### 2.1. Phase I of CAP/I

In phase I, CAP/I examines successive WORDs of a SENTENCE until one of the elements of CCN, THT, PNT or REL is encountered (see Tables 3.1 and 3.3 for definition of these classes). When one of these RELATIONs is encountered, rules for the particular RELATION are applied to the SENTENCE. The purpose of phase I is to make initial

CLAUSE boundary assignments. Other CLAUSE boundaries are added in phase II.

### 2.1.1. Rules for the Class CCN

When an element of CCN is encountered, several checks are made to ascertain that the CCN marks a CLAUSE boundary. No CLAUSE boundary is marked if any of the following conditions is met.

1. The CCN is the first or second element of the sentence.
2. The WORD "," (element of PNT) precedes the CCN.
3. The WORDs "either" or "neither" occur proceeding the CCN elements "or" or "nor," respectively.

If none of these conditions is met, a CLAUSE boundary is marked.

### 2.1.2. Rules for the Class REL

If REL is preceded by PRP, then the PRP is marked as the CLAUSE boundary. If REL is preceded by CCN, the CCN is marked as the CLAUSE boundary. Otherwise, the REL is marked as the CLAUSE boundary.

### 2.1.3. Rules for the Class THT

In the assignment of WORDs to their respective classes by MYRA, THT is treated as a subset of the AMB class. CAP/I recognizes THT and makes several checks to determine whether THT is a CLAUSE marker. THT does not mark a CLAUSE if:

1. THT is the first element of a SENTENCE;
2. THT is preceded by PRP;
3. The CLAUSE in which THT is contained is intiated by PRP;
4. THT is followed by CCN;
5. THT is preceded bv PNT.

### 2.1.4. Rule for the Class PNT

CAP/I identifies any PNT as a CLAUSE boundary unless the PNT is the first or second element of the SENTENCE.

Phase I of CAP/I terminates when

1) each occurrence of CCN, REL, THT and/or PNT in a SENTENCE has been examined;
2) the appropriate rules have been applied; and
3) the preliminary CLAUSE boundaries have been marked.

## 2.2. Phase Two of CAP/I

This phase concerns the application of rules which involve elements of the classes SCN, INF and PTC. When one of these elements is encountered in a SENTENCE, a new CLAUSE is indicated. The rules of phase 2 are described below.

### 2.2.1. Rule for the Class SCN

When an element of SCN is encountered in a SENTENCE, a new CLAUSE boundary is marked. The CLAUSE terminates when a new CLAUSE boundary is encountered or when EOS is reached.

### 2.2.2. Rule for the Class INF

When an element of INF is found, the immediately proceeding PRP is marked as a new CLAUSE boundary. The CLAUSE terminates as for SCN.

### 2.2.3. Rule for the Class PTC

A CLAUSE is marked whenever an element of PTC is found which is immediately preceded by PRP or SCN. If neither PRP nor SCN immediately precedes PTC, the CLAUSE boundary is marked at PTC.

### 2.3. Experimental Results from CAP/I

The procedures of CAP/I are applied to the NAMEs and RELATIONs that have been identified by MYRA. As mentioned in Chapter III, MYRA was tested using three English texts comprising some 6,000 words. The unaltered output of MYRA was used to test CAP/I; hence CAP/I was tested on automatically classified NAMEs and RELATIONs rather than on NAMEs and RELATIONs manually classified. This was done to provide a measure of how MYRA and CAP/I operate together as a system. Sample output produced by CAP/I is given in Figure 4.1. Complete output for the article *The Old Man and the Sea* is given in Appendix C.

Like MYRA, CAP/I is programmed in PL/I for the IBM S/370-165 computer system. 126,000 bytes of main storage are required for the programs and for working storage. CAP/I operates at the rate of 15,000 words per minute.

#### 2.3.1. Identification and Analysis of CAP/I Errors

The output of CAP/I was examined for errors using the same basic criteria as employed in the analysis of errors made by MYRA (Chapter III, Section 3.3). Errors were classified according to whether a CLAUSE was incorrectly identified or incorrectly delimited. For example, if, in the SENTENCE

> The girl sitting on the stair won first prize.

the ADJECTIVAL CLAUSE "sitting on the stair" were not recognized, then one error would be noted for that fact, and one error would be recorded for the fact that the CLAUSE "The girl won first prize" would be

```
303.  The old man had taught the boy
     |               |             |            |
     |DTR ADJ NON|AUX   VRB|   DTR NON|
     |               |             |            |

304.  to fish
     |         |
     |PRP VRB|
     |         |

305.  and the boy loved him.
     |    |        |            |
     |CNJ|DTR NON|  VRB   PRN|EOS
     |    |        |            |
```

Figure 4.1 Sample output produced by CAP/I from _The Old Man and the Sea_.

incorrectly delimited.

The overall results of this error analysis for each of the texts tested are given in Table 4.1. As average accuracy of 62% was found for the delimitation of CLAUSEs, and an average accuracy of 85% was determined for the identification of CLAUSEs.

### 2.3.2. Conclusions From Analysis of CAP/I Results

In analyzing the results of CAP/I, the most significant problem was that of correctly recognizing a CLAUSE. Incorrect CLAUSE recognition also meant incorrect CLAUSE delimitation. Many of the errors committed by CAP/I could be corrected by incorporating rules which examined the patterns of NOMINAL, PRIMARY and SECONDARY PHRASEs. Thus it will be suggested in Section 4 how an improved CLAUSE identification program might be developed to take advantage of such data. The necessary data are provided by the program to be described next.

## 3. Procedures for the Identification of PHRASEs (PAP)

The procedures described in this section have been designed to identify and classify certain COMPOSITE and COMPLEX NAMEs called, in general terms, PHRASEs. Four types of PHRASE are identified by PAP:

NOMINAL PHRASE
PRIMARY PHRASE
SECONDARY PHRASE
ADV PHRASE

The first three PHRASE types have been defined in Chapter II, Section 3.4.3. An ADV PHRASE is defined as any occurrence of the class ADV outside the boundaries of a NOMINAL, PRIMARY or SECONDARY PHRASE.

Table 4.1 Accuracy of the Output of CAP/I.[28]

| NAME of Document | Correct Delimitation of CLAUSEs % | Correct Identification of CLAUSEs % |
|---|---|---|
| "...Precise Definition of 'Algorithm'" | 82% | 59% |
| The Old Man and the Sea | 87% | 76% |
| "The Clavichord..." | 87% | 50% |

---

[28] Based upon input produced by MYRA (see Table 3.7 ).

PAP operates in essentially two phases. In the first phase, certain of the WORD classes identified by MYRA that are linked by CCP are reduced to a single element of the appropriate class. Thus, a sequence such as NON CCP NON would be reduced to NON. In the second phase, PHRASEs are identified, delimited and classified.

## 3.1. Procedures for the Reduction of Certain COMPLEX NAMEs to SIMPLE NAMEs

PAP first examines a SENTENCE for CCPs which conjoin two SIMPLE NAMEs or two SIMPLE RELATIONs. These triples, which are COMPLEX NAMEs, are reduced by PAP to SIMPLE NAMEs or RELATIONs. These new NAMEs or RELATIONs retain the WORD class assignments made earlier by MYRA. The rules for effecting these reductions are as follows.

... NON CCP NON ... ⇒ ... NON ...
... ADJ CCP ADJ ... ⇒ ... ADJ ...
... ADV CCP ADV ... ⇒ ... ADV ...
... VRB CCP VRB ... ⇒ ... VRB ...
... PRP CCP PRP ... ⇒ ... PRP ...
... AUX CCP AUX ... ⇒ ... AUX ...

When the pattern PRN CCP PRN is found, the elements of PRN are examined for the following patterns.

... ('I'|'she'|'he'|'we'|'they') CCP ('me'|'her'|'him'|'us'|'them')
... ('me'|'her'|'him'|'us'|'them') CCP ('I'|'she'|'he'|'we'|'they')

If one of these patterns is encountered, no reduction is effected. Otherwise, the following rule is applied.

... PRN CCP PRN ... ⇒ ... PRN ...

## 3.2. Procedures for the Identification of PHRASEs

In the second phase of PAP, PHRASEs are identified, delimited and typed. The necessary procedures are based upon both the definition of each PHRASE type and upon the order in which NAMEs and RELATIONs that may constitute the PHRASEs occur. The definitions of the four types of PHRASE are given in Table 4.2.

In this phase of PAP, the class of each WORD in the SENTENCE is examined in a left-to-right manner. The class of the first WORD in the SENTENCE determines the type of PHRASE to be delimited at that point. Consider, for example, the following SENTENCE and corresponding classes for each WORD.

| The | boy | quickly | ran | down | the | trail | . |
|---|---|---|---|---|---|---|---|
| DTR | NON | ADV | VRB | PRP | DTR | NON | EOS |

The class of the first WORD in the SENTENCE is DTR. This signals a NOMP (NOMINAL PHRASE) and calls for the application of pattern 1 and 2 of Table 4.2. Since the second element of SENTENCE is NON, either of the patterns is satisfied and the NOMP is isolated.

The next element in our example SENTENCE is ADV, which initiates the application of patterns 17, 18 and 21 (Table 4.2). Since the next SENTENCE element is VRB, pattern 17 is eliminated, as is pattern 21. Hence pattern 18 applies and a PRMP (PRIMARY PHRASE) is isolated.

The remainder of the SENTENCE is processed by PAP in a similar manner. The complete processing of the example SENTENCE by PAP would yield

Table 4.2 Rules for the Identification and Characterization of PHRASEs.

| RULE | WORD CLASS PATTERN REQUIRED | PHRASE TYPE INDICATED | PHRASE LIMITS | |
|---|---|---|---|---|
| | | | INITIAL | FINAL |
| 1. | $DTR^n$ $((ADV^n ADJ)ADJ^n)$NON | NOMP | /DTR | NON/ |
| 2. | $DTR^n((INT\ ADJ)ADJ^n)$NON | NOMP | /DTR | NON/ |
| 3. | $ADJ^n$ NON | NOMP | /ADJ | NON/ |
| 4. | NON | NOMP | /NON | NON/ |
| 5. | INT $ADJ^n$NON | NOMP | /INT | NON/ |
| 6. | PRN | NOMP | /PRN | PRN/ |
| 7. | $PRN_2$ADJ | NOMP | /$PRN_2$ | ADJ/ |
| 8. | REL NOMP | NOMP | /REL | NOMP/ |
| 9. | NEV $AUX^n$((INT)ADV)VRB | PRMP | /NEV | VRB/ |
| 10. | NEV $AUX^n$ | PRMP | /NEV | AUX/ |
| 11. | NEV $PTC^n$ | PRMP | /NEV | PTC/ |
| 12. | NEV 'to' AUX ((INT)ADV)VRB | PRMP | /NEV | VRB/ |
| 13. | NEV 'to' ((INT)ADV)VRB | PRMP | /NEV | VRB/ |
| 14. | $AUX^n$ NEG VRB | PRMP | /AUX | VRB/ |
| 15. | $AUX^n$ VRB NEG | PRMP | /AUX | NEG/ |
| 16. | $AUX^n$((INT)ADV)VRB | PRMP | /AUX | ADV/ |
| 17. | $AUX^n$VRB((INT)ADV | PRMP | /AUX | ADV/ |
| 18. | ADV AUX VRB | PRMP | /ADV | VRB/ |

Table 4.2 (continued)

| RULE | WORD CLASS PATTERN REQUIRED | PHRASE TYPE INDICATED | PHRASE LIMITS | |
|---|---|---|---|---|
| | | | INITIAL | FINAL |
| 19. | ADV VRB | PRMP | /ADV | VRB/ |
| 20. | VRB ADV | PRMP | /VRB | ADV/ |
| 21. | $PRP^n$ NOMP | SECP | /PRP | NON/ |
| 22. | ADV | ADVP | /ADV | ADV/ |
| 23. | PRP (PNT) | ADVP | /PRP | PRP/ |
| 24. | PRP (EOS) | ADVP | /PRP | PRP/ |

The boy quickly ran down the trail.

```
 DTR NON  ADV    VRB  PRP DTR NON  EOS
|  NOMP  |    PRMP   |    SECP    |
```

Processing is terminated when EOS is encountered.

### 3.3. Procedures for the Reduction of Certain COMPLEX NAMEs to PHRASEs

Once PHRASEs have been delimited, it may be found that two or more of them are conjoined by CCP. For example,

```
 DTR NON ADV VRB PRP DTR NON CCP PRP ADJ NON EOS
|  NOMP | PRMP  |    SECP   |   |     SECP    |
```

Under these circumstances, it may be desirable to reduce such a COMPLEX NAME to a PHRASE of the same type as those in the COMPLEX NAME. Such a reduction is accomplished in the same manner as reduction of COMPLEX NAMEs and RELATIONs to SIMPLE NAMEs and RELATIONs (Section 3.1). The following rules serve for the reduction of COMPLEX NAMEs to PHRASEs.

... ADVP CCP ADVP ... ⇒ ... ADVP ...
... NOMP CCP NOMP ... ⇒ ... NOMP ...
... PRMP CCP PRMP ... ⇒ ... PRMP ...
... SECP CCP SECP ... ⇒ ... SECP ...

Thus, in the following example, two NOMINAL PHRASEs are linked by CCP are

The suitcases and packages were left on the plane.

```
 DTR    NON     CCP   NON      AUX  VRB PRP DTR   NON EOS
|    NOMP     |      | NOMP  |    PRMP  |     SECP      |
```

reduced to a single NOMP, hence:

```
 DTR      NON    CCP  NON      AUX  VRB PRP DTR   NON EOS

|                NOMP        |   PRMP   |    SECP       |
```

### 3.3.1. Reductions Not Involving CCP

ADJECTIVAL SECONDARY RELATIONs introduce PHRASEs that may be combined with a preceding NOMINAL PHRASE to form a new NOMINAL PHRASE. To accomplish such a reduction, it is first necessary to distinguish between ADJECTIVAL and ADVERBIAL SECONDARY RELATIONs. The distinction between these two classes is based upon the structure in which the RELATION occurs. The following rules serve to distinguish ADJECTIVAL SECONDARY RELATIONs from ADVERBIAL SECONDARY RELATIONs which are therefore defined by default.

1. The SECONDARY RELATION "of" introduces an ADJECTIVAL SECONDARY PHRASE if it initiates a SECONDARY PHRASE and if it is preceded by a NOMINAL PHRASE.
2. Any SECONDARY RELATION introduces an ADJECTIVAL SECONDARY PHRASE if it initiates a SECONDARY PHRASE that is preceded by a NOMINAL PHRASE and followed by a PRIMARY PHRASE.

An ADJECTIVAL SECONDARY RELATION is considered to be an attribute of the NOMINAL PHRASE which precedes it. Thus, the NOMINAL PHRASE and the SECONDARY PHRASE are reduced to a single NOMINAL PHRASE. As the following example illustrates, the SENTENCE

```
The present for the children was filled with bags of candy.

DTR    NON   PRP DTR    NON    AUX   VRB    PRP  NON  PRP  NON  EOS
|  NOMP    |     SECP        |     PRMP   |   SECP  |   SECP  |
```

becomes[29]

---

[29] By using such procedures, the SENTENCE "The children's present was filled with candy bags." would be assigned the same PHRASE structure.

The present for the children was filled with bags of candy.

```
DTR   NON   PRP DTR   NON    AUX  VRB    PRP  NON PRP  NON EOS
|           NOMP             | PRMP  |          SECP         |
```

## 3.4. Results of Tests

The WORD and CLAUSE assignments produced by MYRA and CAP/I form the input to PAP. PAP was tested on the data generated from the three articles mentioned earlier. An average accuracy of 90% was attained in correctly delimiting PHRASEs and an accuracy of 92% was attained in correctly identifying PHRASEs. The results produced by PAP for each of the three documents analyzed are presented in Table 4.3. Sample output produced by PAP is illustrated in Figure 4.2. More extensive output may be found in Appendix C.

Most of the error which occurred both in delimiting and identifying PHRASEs was caused by errors in MYRA and CAP. Only a small percentage of error was directly caused by the definition of the structure of PHRASE types. A detailed analysis of the results generated by PAP is presented in Appendix E.

In this and the preceding chapter, three programs have been described: MYRA, CAP/I and PAP. The organization of these programs into a system for language analysis is illustrated in Figure 4.3. As alluded to in the discussion of CAP/I, this organization is somewhat illogical in that knowledge of PHRASE boundaries would be of help in identifying and delimiting CLAUSEs, whereas the converse does not hold. Therefore, this organization has been modified as depicted in Figure 4.4. PAP now

Table 4.3 Accuracy of the Output of PAP.[30]

| NAME of Document | Correct Delimitation of PHRASEs % | Correct Identification of PHRASE Type % |
|---|---|---|
| "...Precise Definition of 'Algorithm'" | 90% | 92% |
| *The Old Man and the Sea* | 93% | 94% |
| "The Clavichord..." | 87% | 90% |

---

30. Based upon input produced by CAP/I (see Table 4.1).

```
303.  The old man had taught the boy
     |DTR ADJ NON|AUX   VRB |  DTR NON|
     |           |          |         |
     |  NOMP     |  PRMP    |   NOMP  |
     |           |          |         |


304.  to fish
     |PRP VRB|
     |       |
     | PRMP  |
     |       |


305.  and the boy loved him.
     |CNJ DTR NON| VRB   PRN|EOS
     |           |          |
     |       NOMP|PRMP NOMP |
     |           |          |
```

Figure 4.2 Sample output produced by PAP from The Old Man and the Sea.

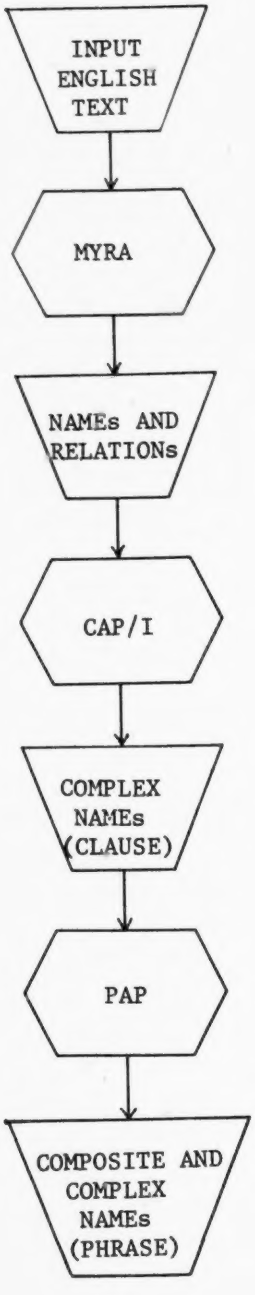
INPUT ENGLISH TEXT
MYRA
NAMEs AND RELATIONs
CAP/I
COMPLEX NAMEs (CLAUSE)
PAP
COMPOSITE AND COMPLEX NAMEs (PHRASE)

Figure 4.3 The operation of the language analysis procedures.

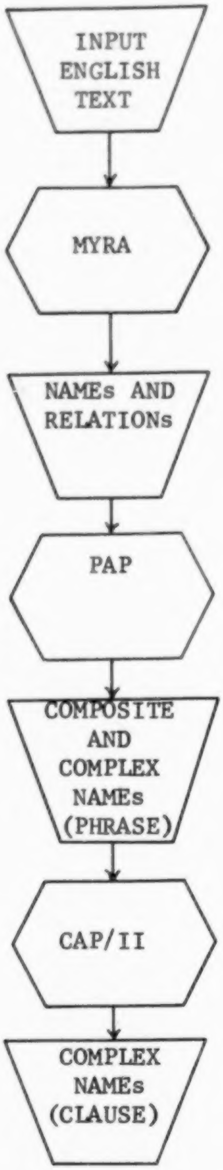
INPUT ENGLISH TEXT
MYRA
NAMEs AND RELATIONs
PAP
COMPOSITE AND COMPLEX NAMEs (PHRASE)
CAP/II
COMPLEX NAMEs (CLAUSE)

Figure 4.4 The operation of the language analysis procedures with the refined version of clause recognition.

derives its input directly from MYRA and a new CLAUSE program, CAP/II, has been designed which accepts input both from MYRA and from PAP. CAP/II is described in the next section.

## 4. Improved Procedures for the Identification of CLAUSEs

CAP/II incorporates not only those procedures embodied in CAP/I, but also contains a number of additional procedures that take advantage of the output of PAP. Phase I of CAP/II corresponds with phase I of CAP/I. Phase II of CAP/II is carried out in the same way as for CAP/I, but now no tests are made involving the classes INF and PTC. After insertion of the CLAUSE markers, the strings are examined to determine the accuracy of the CLAUSE-boundary assignment. If a PRIMARY RELATION is not found within CLAUSE boundaries, one or both boundaries are deleted. If a CLAUSE initiates a SENTENCE, its right boundary is deleted; otherwise a right boundary is deleted until a PRIMARY PHRASE is found or until EOS. If no PRIMARY PHRASE is found, left boundaries are deleted, from right to left until a PRIMARY PHRASE is found. In the next step, CAP/II examines PHRASE patterns to determine whether CLAUSEs are present which have not yet been identified.

### 4.1. Rules for Identifying CLAUSEs which Involve the Class INF

CAP/II contains a number of rules for the identification of CLAUSEs based upon patterns of PHRASEs. Five of these rules involve the Class INF (a class of PRIMARY RELATION). These rules are:

1. ... NOMP PRMP' ... $\Rightarrow$ .../NOMP PRMP' ...

*2. ... PRMP' SECP$^n$ PRMP ... ⇒ .../PRMP' SECP$^n$/PRMP ...

*3. ... PRMP' NOMP SECP$^n$ PRMP ... ⇒ .../PRMP' NOMP SECP$^n$/PRMP ...

*4. ... PRMP' NOMP SECP$^n$ NOMP PRMP ... ⇒
.../PRMP' NOMP SECP$^n$ NOMP/PRMP ...

*5. ... PRMP' SECP$^n$ NOMP ... PRMP ... ⇒
.../PRMP' SECP$^n$/NOMP ... PRMP ...

(where PRMP' is a PRIMARY PHRASE containing INF, $n \geq 1$, "/" marks a CLAUSE boundary and where rules marked with an asterisk are interpreted as placing a clause marker before PRMP' only if rule 1 cannot be applied).

If a PRMP' is immediately preceded by NOMP, the NOMP initiates the CLAUSE. Otherwise, PRMP' initiates the CLAUSE. The right boundary of each CLAUSE identified by rules 2-5 is marked as indicated in the rules.

### 4.2. Rules for Identifying CLAUSEs which Involve the Class PTC

The rules in which PTC is involved are:

6. ... PRMP* SECP$^n$ PRMP ... ⇒ .../PRMP* SECP$^n$ /PRMP ...

7. ... PRMP* NOMP SECP$^n$ PRMP ... ⇒
.../PRMP* NOMP SECP$^n$ /PRMP ...

8. ... PRMP* (NOMP SECP$^n$)$^2$ PRMP ... ⇒
... /PRMP* (NOMP SECP$^n$)$^2$ /PRMP ...

9. ... PRMP* (NOMP SECP$^n$)$^2$ NOMP ... PRMP ... ⇒
.../PRMP* (NOMP SECP$^n$)$^2$/NOMP ... PRMP ...

(where PRMP* is a PRIMARY PHRASE containing PTC, $n \geq 0$ and "/" marks a CLAUSE boundary). PRMP* always initiates a CLAUSE. If PRMP* preceded by a NOMINAL PHRASE, the CLAUSE initiated by PRMP* is ADJECTIVAL (see Figure 2.7, Chapter II), otherwise the CLAUSE is NOMINAL.

### 4.3. Other CLAUSE Identification Rules

After all of the CLAUSE identification procedure so far described have been applied by CAP/II, a final check is made of the SENTENCE for any unidentified CLAUSEs according to the following rules

10. ... PRMP SECP$^n$ PRMP ... ⇒
... PRMP SECP$^n$/PRMP ...

11. ... PRMP SECP$^n$ NOMP PRMP ... ⇒
... PRMP SECP$^n$/NOMP PRMP ...

12. ... PRMP NOMP SECP$^n$ PRMP ... ⇒
... PRMP/NOMP SECP$^n$ PRMP ...

(where $n \geq 0$ and "/" marks a boundary between CLAUSEs). These rules serve only to mark the boundary between CLAUSEs. The remaining CLAUSE boundaries are determined by the other procedures in CAP/II (for instance, EOS would mark the right boundary of a CLAUSE whose left boundary was marked by use of one of the rules 10-12).

Although CAP/II has not been implemented, the procedures which it embodies have been tested manually and have been shown to give much better results than CAP/I. Implementation and testing of CAP/II are currently being carried out.

This chapter has described two programs which are currently in operation (CAP/I and PAP) and has described the design of a third program (CAP/II) which is currently under construction. These programs provide a means for analyzing English text in terms of NAMEs and RELATIONs on several different levels (*i.e.*, SIMPLE NAMEs and RELATIONs, CLAUSEs and PHRASEs.) The output generated by these programs has been illustrated and the accuracy of the result has been detailed. A final program developed in this research, and described in the next chapter, builds upon the results of MYRA, CAP/I and PAP.

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## CHAPTER V. THE FUNCTION OF NAMES AND RELATIONS.

### 1. Introduction

In previous chapters, procedures have been described which identify NAMEs and RELATIONs on several levels of complexity. These procedures are largely structurally based. We turn now to a consideration of procedures which deal with the function of NAMEs and RELATIONs within a SENTENCE. Function is here described in terms of the theory of case grammar formalized by Fillmore (1, 2).

A brief review of the notions of case (in the Fillmorian sense) is presented first, followed by a description of Fillmore's original theory. Then a modification of his theory developed for this research is presented and finally, procedures are described which categorize elements of a SENTENCE according to their function within this framework.

### 2. Case Grammar

The notions of case have been discussed for many years, but commonly in terms that modern linguists find to be of little practical utility. The traditional cases included nominative, genative, dative, and accusative. In contrast, case grammar is concerned with the role played by various elements of a sentence. Thus, typical cases are agent, object, experiencer, beneficiary, locative and so on.

Several intuitive definitions of this type of case role are to be found in the information storage and retrieval literature (3, 4, 5, 6). Case roles are also to be found in one guise or another in the work of Shank and Tesler (7), Winograd (8), Woods (9), Quillian (10) and others. (Some details of the work of these authors have been given in previous chapters.)

Case grammar was first presented by Charles Fillmore in 1966 (1). However, the classic statement of case grammar is found in "The Case for Case" presented by Fillmore in 1968 (2). Fillmore himself has modified his model of case grammar over the past few years (11, 12) and many workers involved in semantic analysis have adopted some form of case grammar. For a detailed description of Fillmore's positions and of work in which modifications of case grammar have been made for specific uses, the reader is referred to (12, 13). The model of case grammar given here differs from those presented by Fillmore in two major respects: first the PRIMARY RELATION is viewed as central and demands certain case roles; second, case roles must depend minimally upon extralinguistic evidence for their identification. The model of case grammar presented below builds upon Fillmore's work, and includes conceptualizations of Chafe and Cook (14, 15, 16, 17, 18).

## 2.1. The Basic Components of Case Grammar

Case grammar postulates that 1) the basic unit of text for analysis is the CLAUSE; 2) a CLAUSE consists of a series of NOMINAL and SECONDARY PHRASEs which are non-linearly related to a PRIMARY PHRASE. PRIMARY PHRASEs are partitioned into several categories, and NOMINAL

SECONDARY PHRASEs are partitioned into categories under the control of the category of PRIMARY PHRASE. A category of NOMINAL or SECONDARY PHRASE is called a case grammar role, or _case role_, The structure of a CLAUSE is represented in terms of the category of the PRIMARY PHRASE and in terms of the case roles assigned to the NOMINAL or SECONDARY PHRASEs. This representation is referred to as a _case frame_.

## 2.2. _Categories of PRIMARY RELATION_

Case grammar defines five categories of PRIMARY PHRASE:

AGENTIVE

BENEFACTIVE

EXPERIENCER

REFLEXIVE

STATIVE

The distinction between these categories is made on the basis of the identity of the MAIN PRIMARY RELATION in the PRIMARY PHRASE. For the BENEFACTIVE category, the MAIN PRIMARY RELATION elements are:

had
has
have
having

The EXPERIENCER category is defined by the following elements of MAIN PRIMARY RELATION.

died
doubt
fear
feel
hear
hope
know
like
love
remember
see
smell
understand
want
wish
wonder

The MAIN PRIMARY RELATIONs in the category STATIVE are:

| | |
|---|---|
| am | being |
| are | is |
| be | was |
| been | were |

Thus, the categories BENEFACTIVE, EXPERIENCER and STATIVE are defined ostensively. The category RELFEXIVE is defined as being comprised of those PRIMARY PHRASEs (other than those in the categories BENEFACTIVE, EXPERIENCER or STATIVE) which are preceded in a CLAUSE by exactly one NOMINAL PHRASE and which are followed by no NOMINAL PHRASE. The category AGENTIVE is defined by default.

## 2.3. Case Roles

Two classes of case role are identified: essential (also called nuclear, propositional or major) and peripheral (also called modal or minor). In an intuitive sense, essential cases are assigned to those elements of a CLAUSE which can be interpreted as answering the questions "who ,""what," "which"; peripheral cases are assigned to elements which answer questions like "when," "how," "why," "where," "for what." In general, essential cases are those demanded by a PRIMARY PHRASE, while peripheral cases are usually, if not always, optional.

The case roles and their definitions, according to Fillmore (19), are given in Table 5.1. As pointed out above, these case roles have been modified somewhat for the purposes of this research. The main purpose of the changes was to enable the identification of case roles by algorithmic means. The case roles used in this work, together with their definitions are presented in Table 5.2. The case roles presented

Table 5.1 Case Roles and their Definitions According to Fillmore (19).

| TYPE | CASE ROLE | SYMBOL | DEFINITION |
|---|---|---|---|
| ESSENTIAL | AGENTIVE | A | instigator of the action, animate |
| | EXPERIENCER | E | affected by the action, animate |
| | INSTRUMENTAL | I | force or object causing action of state |
| | OBJECTIVE | O | semantically most neutral case |
| | SOURCE | S | the origin or starting point |
| | GOAL | G | the object or end point |
| PERIPHERAL | LOCATIVE | L | spatial orientation of the action |
| | TIME | T | temporal orientation of the action |
| | COMITATIVE | C | accompaniment role, animate |
| | BENEFACTIVE | B | benefactive role, animate |

Table 5.2 Definition of Essential and Peripheral Case Roles as Used in the Present Research.

| CASE ROLE | SYMBOL | DEFINITION OF CASE ROLE |
|---|---|---|
| AGENT | A | the source of the action specified by the PRIMARY PRHASE. |
| EXPERIENCER | E | the one who experiences the feeling, sensation, etc., specified by the PRIMARY PHRASE. |
| BENEFICIARY | B | the possessor (in its broadest sense) of some thing, whether the possession be temporary or permanent, positive or negative. |
| OBJECTIVE | O | the receiver of the action described by the PRIMARY PHRASE. |
| LOCATIVE | L | the place where the action described by the PRIMARY PHRASE occurs. |
| TIME | T | the time when the action described by the PRIMARY PHRASE occurs. |
| MANNER | M | the way in which the action described by the PRIMARY PHRASE is performed. |
| COMITATIVE | C | the accompaniment case, a subject accompanying the source of the action described by the PRIMARY PHRASE. |
| CAUSE | Cs | the case giving the reason for the action described by the PRIMARY PHRASE. |
| PURPOSE | P | the case giving the purpose of the action described by the PRIMARY PHRASE. |

by Fillmore (10) are contrasted with those used in the present work in Table 5.3. To give the reader some notion of the applications of case grammar, Table 5.4 presents English sentences illustrative of each of the five categories of PRIMARY PHRASE, together with the case-role assignments for the various elements of each sentence.

## 3. Identification of Case Roles

In this research, case roles are assigned to NOMINAL PHRASEs, SECONDARY PHRASEs and CLAUSEs (a departure from Fillmore's procedures). The conditions under which such assignments are made, as well as the nature of the assignments, will be described in this section. In general, case grammar analysis is carried out on the CLAUSE.

### 3.1. Essential Case Roles

The assignment of essential case roles within the CLAUSE is determined by the following rules.

1. For the AGENTIVE category: A case preceding and E and O cases following the PRIMARY PHRASE in that order, except if the PRIMARY PHRASE is passive,[31] O case preceding and E and A cases following the PRIMARY PHRASE in that order.

2. For the BENEFACTIVE category: B case preceding and O case following the PRIMARY PHRASE, except if the PRIMARY PHRASE is passive[31] in which case these assignments are reversed.

3. For the EXPERIENCER category: E case preceding and O case following the PRIMARY PHRASE, except if the PRIMARY PHRASE is passive[31] in which case these assignments are reversed.

4. For the REFLEXIVE category: A - O case preceding the PRIMARY PHRASE.

---

[31] A passive PRIMARY PHRASE is defined as follows. If the PRIMARY PHRASE is initiated by AUX and if it is followed by a SECONDARY PHRASE introduced by "by" in the same CLAUSE, the PRIMARY PHRASE is passive.

Table 5.3 Case Roles as After Fillmore and as Used in this Research.

| TYPE | CASE ROLES | | SYMBOL |
|---|---|---|---|
| | FILLMORE | PRESENT RESEARCH | |
| ESSENTIAL | AGENT | AGENT | A |
| | EXPERIENCER | BENEFICIARY | B |
| | GOAL | EXPERIENCER | E |
| | INSTRUMENTAL | OBJECT | O |
| | LOCATIVE | | |
| | OBJECT | | |
| | SOURCE | | |
| PERIPHERAL | BENEFACTIVE | CAUSE | Cs |
| | COMITATIVE | COMITATIVE | C |
| | LOCATIVE | LOCATIVE | L |
| | TIME | MANNER | M |
| | | PURPOSE | P |
| | | TIME | T |

Table 5.4 Case-Role Assignments for Sample CLAUSEs each Containing one of the Categories of PRIMARY PHRASE.

| PRIMARY PHRASE CATEGORY | ILLUSTRATIVE EXAMPLES |
|---|---|
| STATIVE | The boy is a man today.<br>O stative O T |
| BENEFACTIVE | I have the book in the library.<br>B benefactive O L |
| EXPERIENCER | The little girl liked ice cream<br>E experiencer O<br>with chocolate syrup.<br>M |
| REFLEXIVE | The bird flew<br>A-O reflexive |
| AGENTIVE | The cyclist hit the car<br>A agentive O |
| | He gave me the letter<br>A agentive E O |

5. For the STATIVE category: O case preceding and/or following the PRIMARY PHRASE.

The case frames to which these rules give rise are summarized in Table 5.5. The way in which these rules are applied is described in Section 4.

### 3.2. Peripheral Case Roles

In general, the assignment of peripheral cases is made to SECONDARY PHRASEs and is controlled by the SECONDARY RELATION which introduces the PHRASE. The time case presents an exception to this general statement. WORDs that signal the time case must be defined ostensively. They are:

again
already
always
day
days
early
finally
first
frequently
later
month
months
never
now
once
still
then
time
today
tomorrow
tonight
week
weeks
when
year
years
yet

If a SECONDARY PHRASE contains one of these WORDs it is assigned the T case. Otherwise, the following rules apply.

1. A SECONDARY PHRASE initiated by "to" is assigned L case.
2. A SECONDARY PHRASE initiated by "by" is assigned M case.
3. A SECONDARY PHRASE initiated by "for" is assigned P case.
4. A SECONDARY PHRASE initiated by "with" or by "without" is assigned C case if the PHRASE contains the NAME of an animate entity,[32] and the M case otherwise.
5. A SECONDARY PHRASE initiated by any other SECONDARY RELATION is assigned L case.

---

32. An animate entity is defined to be any PHRASE containing one of the WORDs he, she, her, him, they, them, we or us.

Table 5.5 Case Frames for Essential Cases as Prescribed by the PRIMARY PHRASE Category.

| CATEGORY | PASSIVE[32] ? | CASE FRAMES |
|---|---|---|
| AGENTIVE | No | A AGENTIVE E, O |
| | Yes | O AGENTIVE E, A |
| BENEFACTIVE | No | B BENEFACTIVE O |
| | Yes | O BENEFACTIVE B |
| EXPERIENCER | No | E EXPERIENCER O |
| | Yes | O EXPERIENCER E |
| REFLEXIVE | --- | A-O REFLEXIVE |
| STATIVE | --- | O STATIVE |
| | | O STATIVE O |

[32] A passive PRIMARY PHRASE is defined as follows. If the PRIMARY PHRASE is initiated by AUX and if it is followed by a SECONDARY PHRASE introduced by "by" in the same CLAUSE, the PRIMARY PHRASE is passive.

The way in which these rules are applied is described in Section 4.

## 3.3. Assignment of Case Roles to CLAUSEs

In addition to the case-role assignments described above, work has begun to define the case roles of CLAUSEs. This is a major extension of the original Fillmorian conception of case, one that follows logically from the NAME/RELATION view of language espoused in this dissertation. The rules which have so far been developed for the assignment of case roles to CLAUSEs are restricted to CLAUSEs which contain an element of PTC and which are initiated by a SECONDARY RELATION. The rules are:

1. A CLAUSE initiated by "from" receives the Cs case (e.g., His hands were tough from handling heavy cords.).
2. A CLAUSE initiated for "for" receives the P case (e.g., The equipment was used for testing compounds.).
3. A CLAUSE initiated by "by" receives the M case (e.g., He tested the compounds by using a new method.).
4. A CLAUSE initiated by "with" receives the O case (e.g., She was finished with typing the dissertation.).
5. A CLAUSE initiated by "of" and preceded by the sequence VRB ADJ receives the O case (e.g., I am sick of making cakes.).
6. A CLAUSE initiated by "of" and preceded by a NOMINAL PHRASE is adjectival and receives the same case as the preceding NOMINAL PHRASE (e.g., The process of making clay.).

## 4. The Case Grammar Program, CGP

The definitions and rules presented in the preceding section have been incorporated into a program called CGP. The program is written in PL/I for the IBM 370-165 computer system and requires 126,000 bytes of main storage. Execution times are in the range 15,000 words per minute. CGP accepts as input the output of MYRA, PAP and CAP/I. It operates in two phases. Phase I is concerned with the categorization of the PRIMARY PHRASE within the CLAUSE. STATIVE, BENEFACTIVE and EXPERIENCER categories are determined by dictionary look-up. The REFLEXIVE category is determined by considering the number of NOMINAL PHRASEs surrounding the PRIMARY PHRASE. If only one is found and it precedes the PRIMARY PHRASE, the category REFLEXIVE is identified. All other PRIMARY PHRASEs are AGENTIVE.

After the PRIMARY PHRASEs have been categorized, the essential cases are assigned. Such assignments generally follow the rules of Section 3.1. In addition, if SECONDARY PHRASEs containing NAMEs indicative of animate objects are introduced by the SECONDARY RELATIONs "to" or "for", the SECONDARY PHRASE is assigned the E or B case, respectively.

Peripheral cases are assigned to SECONDARY PHRASEs based upon the rules given in Section 3.2. Case assignments to CLAUSEs follow the rules of Section 3.3.

A flow diagram of CGP is given in Figure 5.1, and typical results produced by the program are illustrated in Figure 5.2. More extensive output will be found in Appendix C.

### 5. Experimental Testing of CGP

The case grammar program CGP was tested using the same documents as processed by MYRA, CAP/I and PAP. The output from these three programs formed the input to CGP. The results were analyzed by comparing

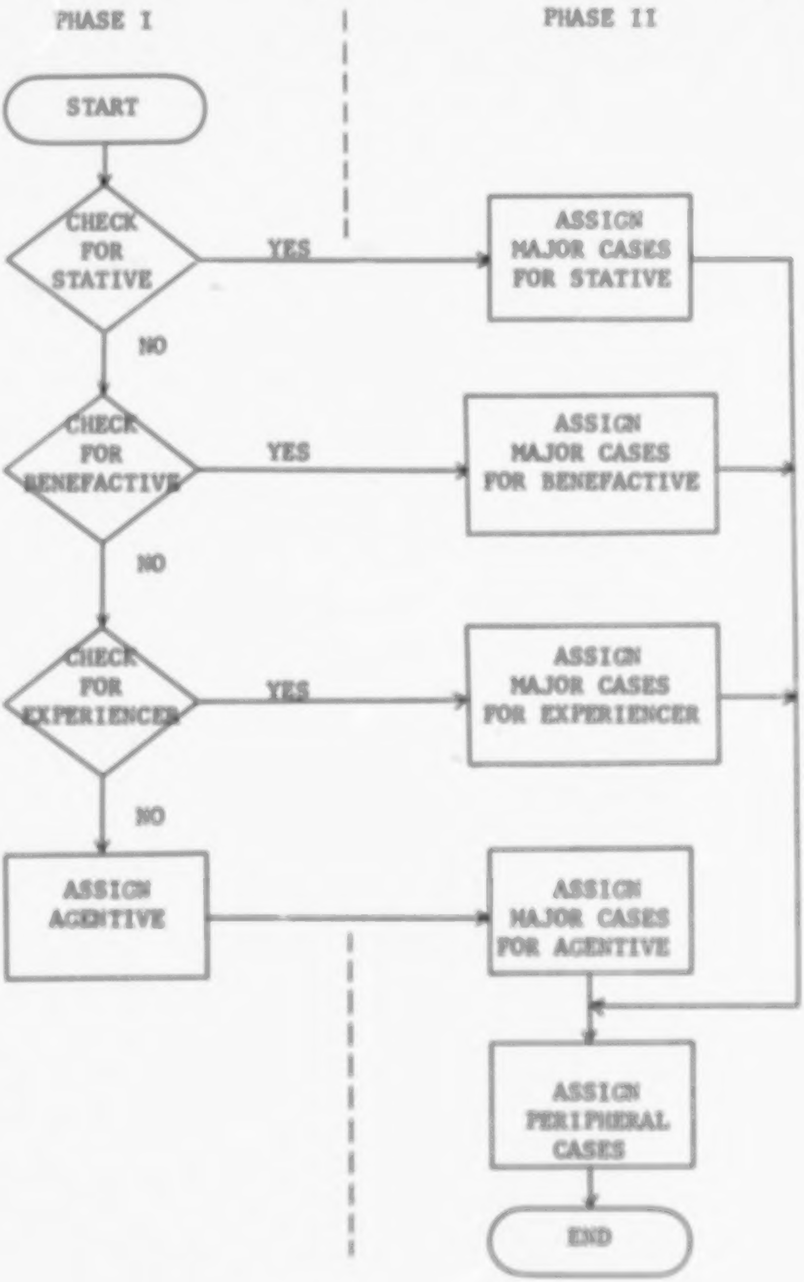
PHASE I
PHASE II
START
CHECK FOR STATIVE
YES
NO
ASSIGN MAJOR CASES FOR STATIVE
CHECK FOR BENEFACTIVE
YES
NO
ASSIGN MAJOR CASES FOR BENEFACTIVE
CHECK FOR EXPERIENCER
YES
NO
ASSIGN MAJOR CASES FOR EXPERIENCER
ASSIGN AGENTIVE
ASSIGN MAJOR CASES FOR AGENTIVE
ASSIGN PERIPHERAL CASES
END

Figure 5.1 A flow diagram of CGP.

```
303.  The old man had taught the boy

     |DTR ADJ NON|AUX   VRB |  DTR NON|
     |           |          |         |
     |  NOMP     |  PRMP    |  NOMP   |
     |           |          |         |
     |  AGENT    |          |  OBJECT |


304.  to fish
     |
     |PRP VRB|
     |       |
     | PRMP  |
     |       |


305.  and the boy loved him .

     |CNJ DTR NON   VRB   PRN|EOS
     |                       |
     |      PRMP       PRMP  |
     |                       |
     |      AGENT            |
```

Figure 5.2   Sample output produced by CCP from <u>The Old Man and the Sea</u>.

the cases assigned with the cases I would intuitively expect for the construction. Differences between assignment and expectation were treated as errors committed by CGP. The results of this error analysis are given in Table 5.6. PAP and CGR operate in 126,000 bytes of storage at the rate of 7,700 words per minute.

## 6. Summary

The program described in this chapter represents the first implementation of case grammar. While the accuracy achieved was only in the range of 75%, many of the errors were due not to CGP, but to the programs which produced the input to the case grammar program. Given accurate input, CGP may reasonably be expected (based upon preliminary studies) to achieve greater than 95% accuracy. Further work to refine the case grammar program are currently under way.

Table 5.6 Accuracy Attained in Case Grammar Assignment Made by CGP.

| DOCUMENT | ACCURACY ATTAINED |
|---|---|
| "..Precise Definition of 'Algorithm'" | 70% |
| _The Old Man and the Sea_ | 83% |
| "The Clavichord and How to Play It" | 65% |

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# CHAPTER VI. LANGUAGE ANALYSIS AND INDEXING

> By definition, the function of a metalanguage in semantic analysis is to singularize or to differentiate--the two notions are interchangeable--the documents of a corpus by the interplay of complex correspondances between natural language formulations and equivalent expressions in a metalanguage.
>
> J. C. Gardin, Semantic Analysis Procedures in the Sciences of Man

## 1. Introduction

In previous chapters of this dissertation a series of language analysis procedures has been described. These procedures are largely syntax based; the strongest appeal to interpretational characteristics is made in the case grammar analysis procedures of Chapter V. In the present chapter, procedures are outlined which permit the construction of structural representations of English sentences (the metalanguage of Gardin (1)). Since the basic purpose for all the work described in this document is the development of means of producing improved indexes, a brief statement of how such structural representations relate to indexing is in order. Following that, a review of some closely related work is given. The remainder of the chapter is then devoted to a discussion of the proposed structural representations.

## 2. Indexes and Indexing

It is conventional to mention the exponential growth of the literature of various fields as the main cause of the difficulty one meets in trying to find data pertinent to his needs. The quantity of documents makes researching the literature difficult, but this difficulty is not the central problem in the array of problems which the information storage and retrieval specialist hopes to solve. In fact, a statement made some 300 years ago by Howell is still adequate to sum up the important problem which must be solved if published data are ever to be readily accessible when one needs the data:

> The reason why there is no Table or Index added hereunto is, that every page is so full of signal remarks that were they couched in an Index it would make a volume as big as the book and so make the Postern Gate to bear no proportion to the building. (2)

Much work has been done to overcome the problem which Howell solved by deciding not to include an index to his book at all. Most of this work has been directed toward increasing the amount of data present in indexes, without a concomitant increase in physical size of the index. If one can speak of "data density," these efforts have all been directed toward increasing the "data density" of the index. One of the very popular techniques has been that of keyword indexing. The central assumption of keyword indexing is that more complex concepts (data) can be formed at search time through approproate application of Boolean algebraic functions (relations) to combinations of keywords. The inadequacy (3) of such an approach is due to the fact that most of the relationships which humans impute between data elements cannot be expressed in terms of any combination of Boolean functions. As a consequence of the failure of keyword indexing to yield satisfactory indexes, attempts to improve keyword indexing, to expand uniterm indexing to multi-term indexing (4), to improve keyword-in-context indexes (5), to produce articulated indexes (6), to simulate human memory (7), and to produce general representations of language (8) have been made which are all concerned with retention (and explication) of relations among data elements.

It might be reasonable to suppose that a document is its own best representation as Howell concluded. But this supposition rests upon the further assumption that the words in the document have the same significance for the reader as for the author. Thus, two important factors must be accounted for in indexing any document. These factors are:

1) The structural properties of a document. (A document conveys data to the reader through the unique organization of language elements within the document.)
2) The interpretational characteristics of a document. (A document conveys data to the reader through the significance imputed to these language elements outside the framework of that document.)

Much attention has been paid the latter factor. Thesauri, authority lists, dictionaries and other devices have been proposed, discussed, designed, built, used and scrapped by many workers. At the same time, the organization and structure of the document has been treated (when recognized at all) as something to be got over as soon as possible. As a result of this attitude, documents are deliberately shorn of the relations they contain at the indexing stage.

To improve indexes, indexing methods must be developed which

a) retain as much of the data contained in a document as possible;

b) retain and make explicit relationships among elements of these data;

c) add data not expressed in a document but which derive from relations among elements of data _in_ a document and elements of data contained in analysis documents (such as thesauri and dictionaries);

e) develop efficient methods for deriving the index material from text, with scant appeal to the "meaning" of text data.

This research has been directed toward the development of language analysis procedures through which one might achieve these aims. In Section 4.3 evidence will be presented to demonstrate the extent to which these goals have been realized. For now, an indication of how language analysis relates to indexes is in order.

### 3. Indexing Theory

An indexing system may be characterized, after Landry (9), as in Figure 6.1. In this model, four major components are identified, the input-document space, $\mathcal{D}_i$; the analysis-document space, $\mathcal{D}_a$; the index space, $\mathcal{I}$; and the several indexes, $I_1$, $I_2$, ..., $I_n$, which the system is capable of producing. The indexing system embodies a set of procedures or mappings from input documents to index(es). These procedures are part of the document space $\mathcal{D}_a$. They operate on input

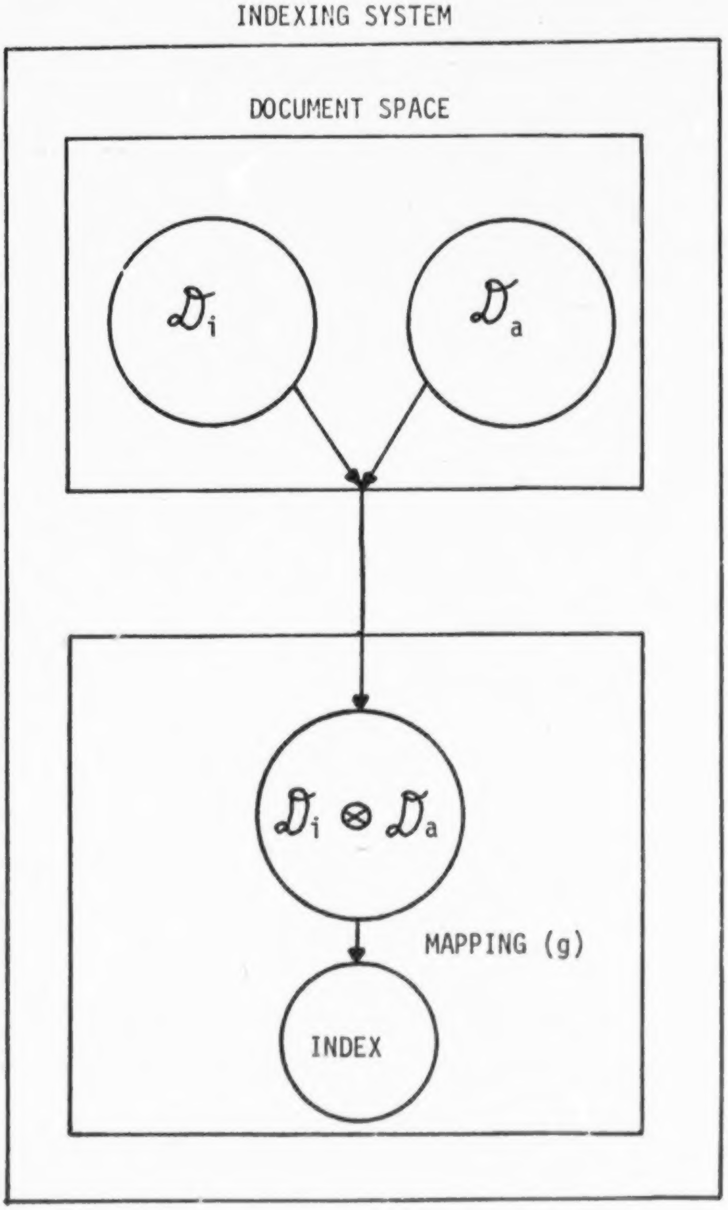

INDEXING SYSTEM
DOCUMENT SPACE
$\mathcal{D}_i$
$\mathcal{D}_a$
$\mathcal{D}_i \otimes \mathcal{D}_a$
MAPPING (g)
INDEX

Figure 6.1 An indexing system as characterized by Landry (9).

documents first to create the document space $\mathfrak{D}_i$, then on the elements of $\mathfrak{D}_i$ to produce the index space, and finally on the index space to produce an index. The index space is a space whose dimensionality is determined by the number of attributes the procedures in $\mathfrak{D}_a$ ascribe to the input documents. In general, the higher the dimensionality of the index space the greater the variety and adequacy of the indexes the system can produce. Thus, the index space corresponds to a meta-representation of the input documents. The fidelity of this representation is a function of its dimensionality.

For the present research, the significance of these observations is that the analysis procedures described in Chapters III-V correspond to Landry's analysis documents and, since they identify a fairly large number of attributes of the input text, they may be supposed to produce an index space of high fidelity. While unequivocal evidence in support of this supposition cannot be given, its partial verification is discussed in the last part of this chapter. The index space may, I think, be viewed in terms of structural representations of language. The nature and derivation of such representations are discussed below.

## 4. Procedures for the Graphic Representation of Sentences

In the remainder of this chapter I describe a graphic representation of English sentences which I propose as an approximation to Landry's index space (10). The procedures outlined for generating this representation are, I believe, sufficient to permit their implementation with little difficulty. This chapter is not concerned, however, with the exact methods for such implementation nor with the graph theory which might be pertinent. It is recognized that the mathematical theory involved in the storage, matching and construction of graphs is an important undertaking, but one whose magnitude is beyond the scope of this work.

## 4.1. Why a Graphic Representation?

It is well-known that English is not strictly linear even though it is produced in a linear fashion (11). This fact is easily illustrated by sentences containing embedded clauses, as

> Sentences that contain embedded clauses have a non-linear structure.

For indexing, the import of this observation is that the specific relationships which are assigned to elements of a sentence are often not immediately obvious from the linear sequence that we call a sentence. But if an algorithmic way of explicating these relationships, that is, of producing a graphical representation of English text, could be devised it might be possible to derive indexes of various kinds from a single representation. Perhaps more important, the representation itself could serve as a kind of index which a person could access directly. Work most closely related to what I shall describe is that of Fugmann and his colleagues (12). This group has devised a machine-aided system for the production of graphic representation of patent literature which they believe will lead to considerably improved information retrieval systems. This work, as well as other related work is discussed in the next section.

### 4.2. Approaches to the Graphic Representation of Language

By way of preamble, it must be noted that the graphic representations which are of interest here are those involving directly the elements of a sentence. Hence, I exclude from consideration all those grammatical studies in which parse trees of various kinds are generated (or proposed).

Many researchers have recognized the value of graphic representation of sentences. Several approaches to the representation of language in graphic form are reviewed briefly below.

#### 4.2.1. Graphic Structure Proposed by Salton

Salton has suggested graphs that represent sentences as an aid in each component of his information storage and retrieval system: analysis, identification, normalization and matching. Salton proposes representing sentences by using tree structures (a graph which has at most one branch entering each node and which contains no circuits (13)). The sentences are analyzed by using a dependency grammar in which the verb is the fulcrum, or central relator of the sentence (14). The graphs contain explicit syntactic relations such as noun-verb and noun-preposition. Semantic relations such as identity and location are also suggested as components of the graph. An example of such a graph is shown in Figure 6.2.

#### 4.2.2. TOSAR Graphs

A somewhat different approach to the construction and use of graphs is that developed by Fugmann, Nickelsen, Nickelsen and Winter (12), involving the intellectual construction of graphs for use in the automated

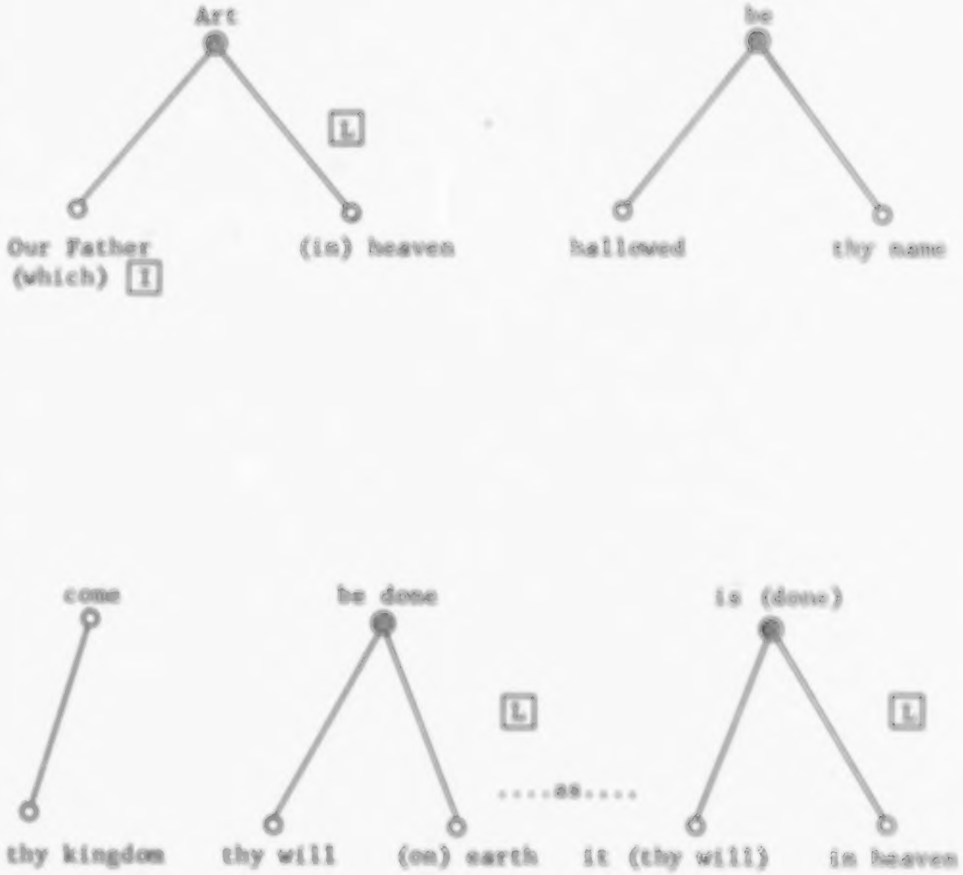
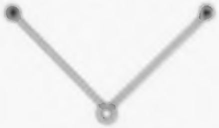
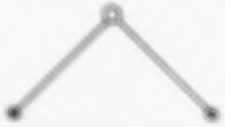

Art
L
Our Father
(which) I
(in) heaven
be
hallowed
thy name
come
thy kingdom
be done
thy will
(on) earth
L
....as....
is (done)
it (thy will)
in heaven
L

Figure 6.2 Graphic representation proposed by Salton. ($\boxed{I}$ = Identity; $\boxed{L}$ = Location) (15).

storage search and retrieval of concepts. The concepts used in the chemical literature lend themselves to graphic representation and hence provide a good starting point for investigation. In the graphic model TOSAR (Topological Method for the Representation of Synthetic Analytical and Relations of Concepts) developed by this group, relations between concepts are represented by lines which join the concepts. Nodes labelled with Roman letters represent substances and nodes labelled with a Greek letter represent processes. Each level of the graph represents a particular stage of a complex process. Thus the graph A characterizes the combination of two substances (by means of an unspecified process) while graph B characterizes the separation of a substance into two components (again without specifying the process). An example of a graph



graph A



graph B

produced via the TOSAR model is given in Figure 4.3.

### 4.2.3. Graphic Representation of Deep Structure

One purpose of the TOSAR model is the adequate representation of a concept which embodies several possible index entries. While chemical literature especially lends itself to this type of analysis, the developers of TOSAR believe that more investigation is needed to define all the concepts in a document in this way (16). An effort in this direction is the Conceptual Dependency Parser (CDP) developed by Schank and Tesler (17). The relevance of the CDP lies in its

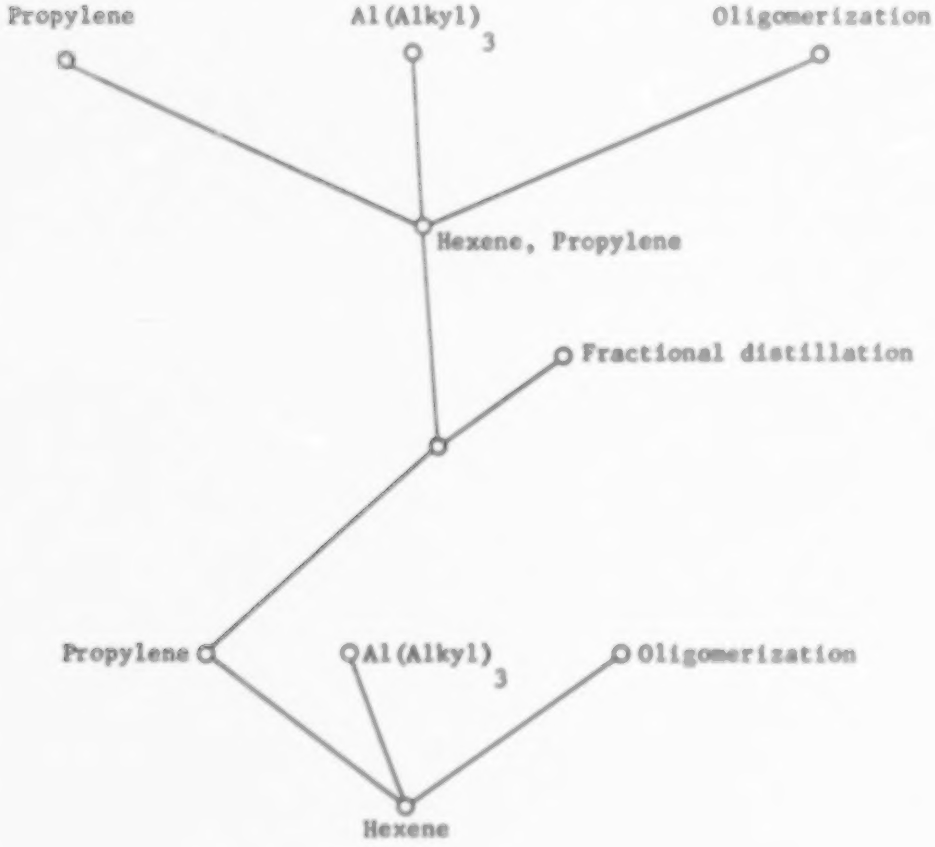

Propylene
Al(Alkyl)$_3$
Oligomerization
Hexene, Propylene
Fractional distillation
Propylene
Al(Alkyl)$_3$
Oligomerization
Hexene

Figure 6.3 A graph produced via the TOSAR model of the sentence: Oligomerization of propylene with the aid of Al(Alkyl)$_3$ to obtain hexene, and separation and purification of the excess propylene by fractional distillation and recycling of the propylene (18).

similarity to case grammar and in its emphasis on the relational attributes of a sentence. According to Schank and Tesler, the CDP is an approach to the identification of the "underlying meaning" of a sentence. Noun phrases are assigned membership in a "governing" or an "assisting" class, and are assigned roles such as "actor" or "participant." Each word contained in the vocabulary of the parser is defined by a list of attributes similar to those suggested by Katz and Fodor (19). If two words occur which have incompatible or undefined attributes, the system must be updated to include the necessary relationship. An example obtained from the CDP is given in Figure 6.4 using the sentence "John's love is good.". Each type of arrow (arc) depicts a different kind of relationship. Presumably, the sample sentence is broken down into two "concepts": "John loves" and "One (John's love) is good." The work of Schank and Tesler represents an attempt to acquire a more profound analysis of sentences than the current state of the art can provide.

### 4.2.4. Graphic Structures Proposed by Plath

Two other programs which must be mentioned have each been implemented for languages other than English. A program has been implemented which constructs diagrams of Russian sentences (20). The program is based on a projective grammar[33] and is used as a method of presenting the output of a predictive syntactic analyzer. The results have also been used to classify and analyze sentences according to their structural properties. An illustration of Plath's results is given in Figure 6.5.

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[33] A grammar similar to an immediate-constituent grammar.

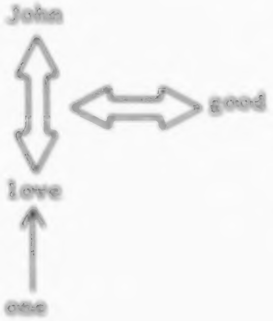

John
good
love
one

Figure 6.4 The "underlying meaning" of the sentence "John's love is good." as represented by the Conceptual Dependency Parser (17).

AUTOMATICALLY GENERATED
SENTENCE DIAGRAM

```
CLAUSE INDICATOR
  NAPRJAZHENIJA
    NA
      KONDENSATORAX
  OTSCHITYVAJUTSJA
   NA
     EKRANE
       OSTSILLOGRAFA
          KATODNOGO
```

IMPLIED NODAL
INTERCONNECTIONS

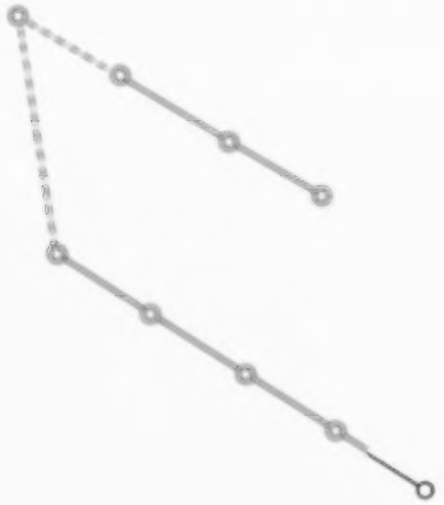


Figure 6.3 Plath's Automatically Produced Sentence Diagrams (20).

### 4.2.5. Graphic Structures Proposed by Tesniere

The second program has been implemented for French sentences by Tesnieré (21). In this research the language is partitioned into four classes: verb, substantive, adjective and adverb. The verb is treated as the central relator of the sentence. Tesniere theorizes that the words of the sentence are more significant the lower they are on the graph. Thus, in the example sentence in Figure 6.6, "vert" and "libre" would be the most significant words.

## 4.3. A Proposal for the Production of Graphic Representations of English Sentences

### 4.3.1. Definition of Components

The production of a graphic representation of an English sentence hinges upon the relational elements of a sentence. A subgraph is produced for each string which contains a PRIMARY RELATION, and then the relationships between these subgraphs are established to produce a graph. Such a process could, in principle, be extended beyond sentence boundaries. The SECONDARY RELATIONs are represented by the arcs of the graph. All other elements are represented as nodes of the graph. COMPOSITE NAMEs (*i.e.*,NOMINAL PHRASEs) are represented as single nodes for simplicity in presentation. The individual elements of a COMPOSITE NAME could be represented as distinct nodes of the graph, and the relationships could be indicated by the arcs which join these SIMPLE NAMEs. The desirability of doing this depends upon the particular use intended for the graph.

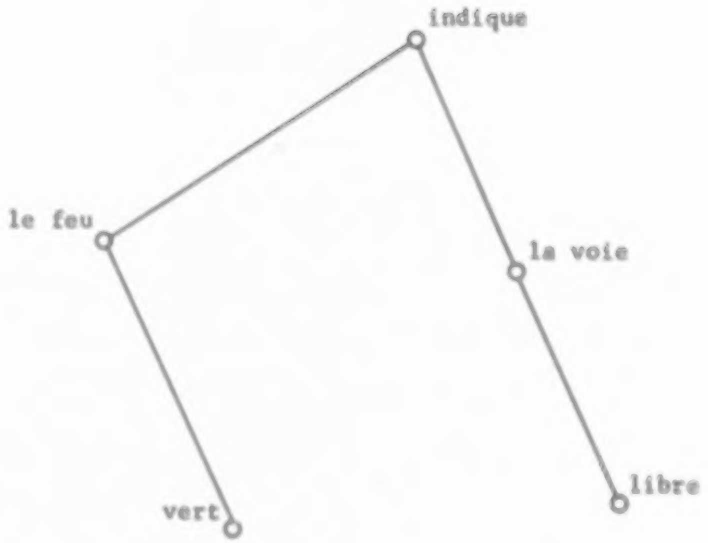

indique
le feu
la voie
vert
libre

Figure 6.6 Tesnier's analysis of the sentence "Le feu vert indique la voie libre." (The green light indicates clear passage.) (21)

Nodes of the graph will be distinguished as NAME nodes (N-nodes) and PRIMARY-RELATION nodes (PR-nodes). Again for simplicity of presentation, N-nodes will be labelled with capital Roman letters instead of the specific NAME, and PR-nodes will be specified by geometric shapes (see Table 6.1).

### 4.3.2. Representation of PRIMARY-RELATION Nodes

A PRIMARY RELATION will appear as a node (called a PR-node) in a graph, the form of which identifies the case-grammar class to which the PRIMARY RELATION belongs. Arcs extend from the PR-node in such a way that the direction of the link between the PRIMARY RELATION and its arguments (NAME) is indicated. If the PRIMARY RELATION is RECESSIVE, the symbol for the node indicates this fact. Specifically, PARTICIPIAL MAIN RECESSIVE PRIMARY RELATIONs are denoted by a darkened node and INFINITIVAL MAIN RPRs are denoted by a shaded node. Table 6.1 lists the node symbols which will be used for the various categories of both DOMINANT and RECESSIVE PRIMARY REALTIONs.

### 4.3.3. Representation of Case Types and COMPOSITE NAMEs

The SECONDARY RELATIONs of a sentence are represented by the arcs of the graph. Since SECONDARY RELATIONs always have two arguments, the arc makes explicit the arguments of the RELATION. The direction of the arc will always be from the second argument to the first. The case role assignment to the second argument of a SECONDARY RELATION is retained to further specify this RELATION. The case role is indicated by a numeral over the arc. The numerical codes corresponding to the case types are given in Table 6.2. An example should clarify these

Table 6.1 Symbols Used to Represent Case Grammar Classes of PRIMARY RELATIONs.

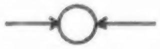
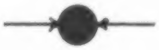
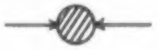
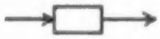
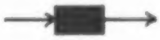
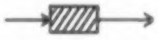
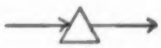
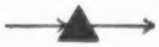
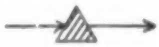
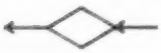
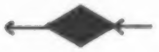
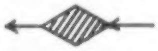
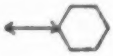
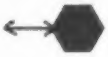
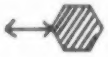
| PRIMARY RELATION TYPE (CASE) | SYMBOLOGY | | |
|---|---|---|---|
| | DOMINANT | RECESSIVE | |
| | | PARTICIPIAL | INFINITIVAL |
| Stative |  |  |  |
| Agentive |  |  |  |
| Experiencer |  |  |  |
| Beneficiary |  |  |  |
| Reflexive |  |  |  |

Table 6.2 The Case Roles Along with the Corresponding Numerical Codes Used in the Graphic Representation.

| CASE ROLE | NUMERICAL CODE |
|---|---|
| Agent | 1 |
| Object | 2 |
| Experiencer | 3 |
| Beneficiary | 4 |
| Location | 5 |
| Time | 6 |
| Manner | 7 |
| Comitative | 8 |
| Cause | 9 |
| Purpose | 10 |
| Facet | 0 |

issues. Suppose we have, in prefix notation (cf., Chapter II, Section 3.4.4),

$$h_2 AB$$

This would be represented in graphical form as

$$A \leftarrow B$$

Likewise, the sentence fragment

$$\underbrace{\text{The boy}}_{A}\ \ \underset{h_2}{\text{in}}\ \ \text{the}\ \underbrace{\text{red shirt}}_{B}\ \ldots$$

would be represented graphically as

$$A \xleftarrow{\quad 0 \quad} B$$

The item "facet" listed along with the case types, is not a case type but indicates an unmarked adjectival relationship. Recall that a case is assigned to a SIMPLE or COMPOSITE NAME. A NAME which implicitly modifies a second NAME does not, therefore, receive a case grammar assignment. Also, it is important to note that the case role is that of the node from which an arc emanates.

### 4.3.4. Representation of Consecutive SECONDARY PHRASEs

A construction which presents difficulty in analysis is a COMPLEX NAME consisting of a succession of SECONDARY PHRASEs. The difficulty which this construction poses is that of correctly identifying the first argument of the pair required by the SECONDARY RELATION (recall that the second argument of the pair always immediately follows the

SECONDARY RELATION). Consider the sentence:

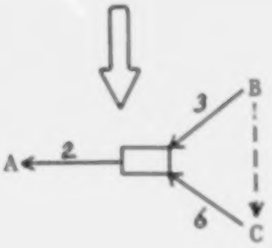
$$\underbrace{\text{The exam}}_{A}\quad \underbrace{\text{was given}}_{b_1}\quad \underset{i_2}{\text{to}}\quad \underbrace{\text{the girl}}_{B}\quad \underset{i_2}{\text{in}}\quad \underbrace{\text{the library}}_{C}.$$

For the first SECONDARY RELATION, $i_2$ the two required arguments are A and $b_1$. But for $i_2$ it is not possible to determine unequivocally whether the arguments are $b_1$ and B or B and C. Traditional grammar would employ a proximity rule which states that a noun phrase modifies the noun or verb phrase to which it is nearest. While this rule might eliminate much confusion, it would place a severe restriction on the interpretation of the sentence. The solution I propose is the following. Since the PRIMARY RELATION is the central RELATION of a SENTENCE, all NAMEs are related, at least indirectly, through the PRIMARY RELATION. All ADVERBIAL SECONDARY RELATIONs (see Section 3.4) will therefore take as their first arguments the PRIMARY RELATION of the CLAUSE in which the SECONDARY RELATIONs are found. But this somewhat arbitrary decision makes it desirable for the graphic structure to contain an indication of the linear order of the phrases in the sentence. Such an indication is provided by a dashed arrow drawn from the COMPOSITE NAME of a SECONDARY PHRASE to the COMPOSITE NAME of the SECONDARY PHRASE which immediately precedes it in the CLAUSE. For example,

$$\underbrace{\text{The exam}}_{A}\ \underbrace{\text{was given}}_{\boxed{\phantom{xx}}}\ \text{to}\ \underbrace{\text{the girl}}_{B}\ \text{in}\ \underbrace{\text{the library}}_{C}.$$

$\underbrace{\text{The exam}}_{A}$ was given to $\underbrace{\text{the girl}}_{B}$ in $\underbrace{\text{the library}}_{C}$

□



The dashed arrow is thus an ordering relation such that "B - - -➔ C" implies B precedes C in the sentence from which the graph was derived.

### 4.3.5. Representation of PHRASEs Related by COORDINATE CONJUNCTIVE SECONDARY RELATIONs

The particular elements of CCP found in a SENTENCE may be important to the interpretation of the SENTENCE. Thus, each member of CCP is represented in a graph as an arc labelled with a numeral (see Table 6.3.). In principle, there may be any number of PHRASEs joined by an element of CCN. Each PHRASE which is part of such a series is linked to the next in succession by a dashed arc which indicates their sequential order. The following examples serve for illustration.

$\underbrace{\text{The meal}}_{A}$ consisted of cheese, bread and wine.

□ B C D

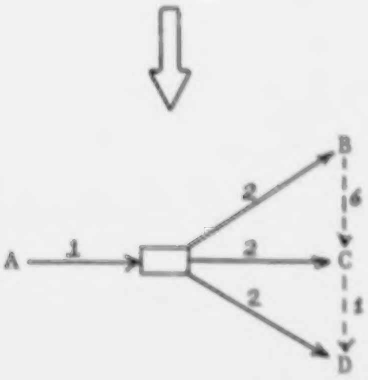
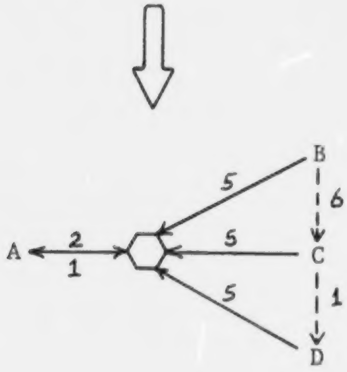


Table 6.3 COORDINATE CONJUNCTIVE SECONDARY RELATIONs and their Corresponding Numerical Codes.

| Element | Numerical Code |
|---|---|
| and | 1 |
| or | 2 |
| but | 3 |
| nor | 4 |
| not | 5 |
| , | 6 |

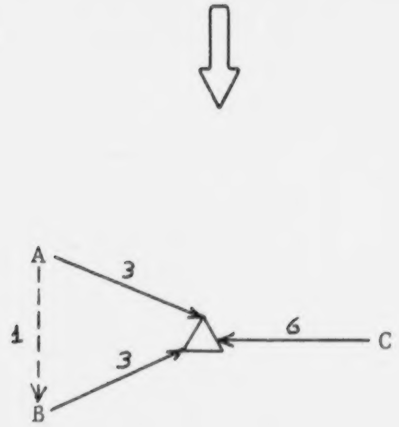
The dog ran across the field, over the bridge and down the lane.

A ⬡ B C D


B
5
6
A
2
1
5
C
5
1
D

Students and faculty were hurt during the riots.

A B △ C

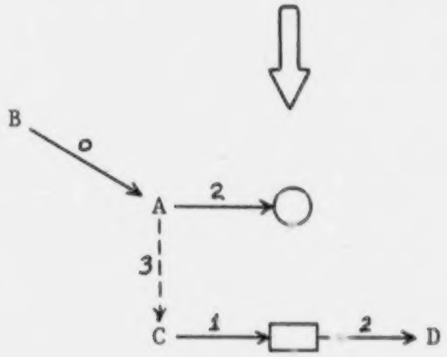


### 4.3.6. Representation of CLAUSEs Joined by CCN

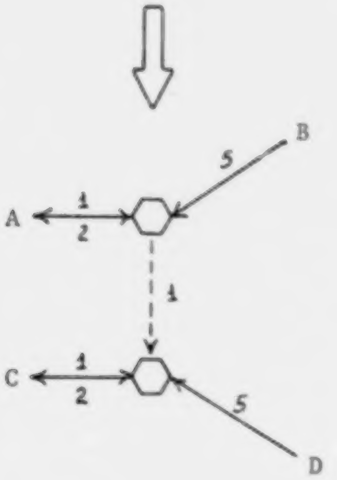
Clauses joined by element of CCN generally have a common element such as a PRIMARY RELATION or a NOMINAL PHRASE. If there is a common NOMINAL PHRASE, the right-most NAME of the first NOMINAL PHRASE of one CLAUSE is compared with the right-most NAME of the NOMINAL PHRASE of the second CLAUSE. If these NAMEs are the same the CLAUSEs are joined by an arrow connecting the NOMINAL PHRASEs. Otherwise, an arc is drawn connecting the PRIMARY RELATION of each CLAUSE. Again, the direction of the arc indicates the order of the CLAUSEs. The following examples illustrate this treatment.

$\underbrace{\text{High-level languages}}_{A}\ \underset{\bigcirc}{\text{may}}\ \text{be}\ \underset{B}{\text{expensive}}\ \text{but}\ \underbrace{\text{assembler language}}_{C}$

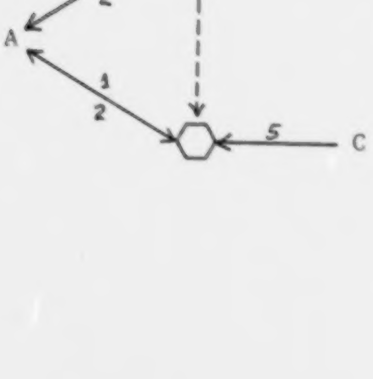
$\underset{\Box}{\text{requires}}\ \text{more}\ \underbrace{\text{specialized personnel}}_{D}.$



$\underbrace{\text{The men}}_{A}$ worked ⬡ in $\underbrace{\text{the field}}_{B}$ and $\underbrace{\text{the women}}_{C}$ worked ⬡ in $\underbrace{\text{the barn}}_{D}$.



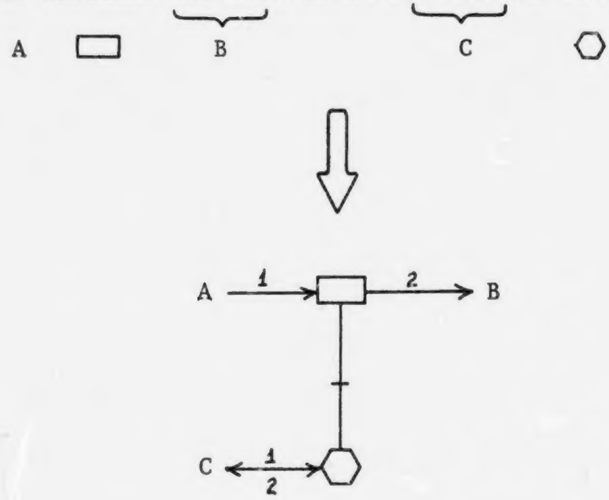
$\underbrace{\text{The boy}}_{A}$ jumped ⬡ out $\underbrace{\text{the window}}_{B}$ and fell ⬡ into $\underbrace{\text{the net}}_{C}$.

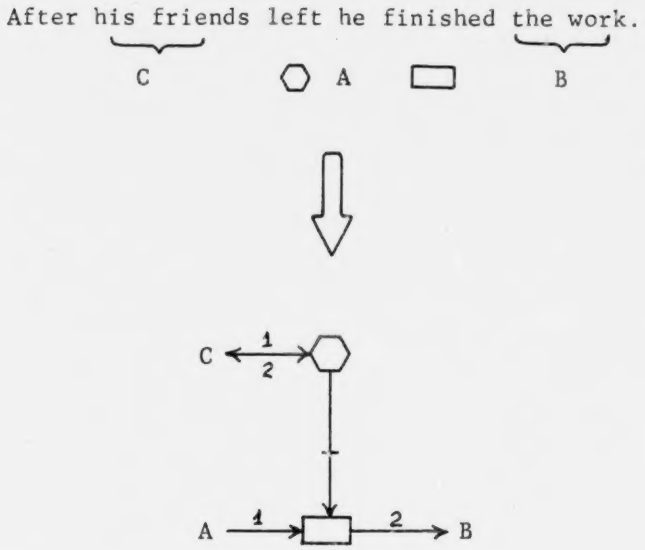


### 4.3.7. Representation of CLAUSEs Joined by SCN

Two clauses which are joined by an element of SCN are connected by a marked arc (—+→). The arc is always darwn from the CLAUSE initiated by SCN to the second CLAUSE. If desired, the ordering of the CLAUSEs is easily preserved. The following examples illustrate how CLAUSEs joined by an element of SCN are depicted and how the ordering of CLAUSEs can be preserved.

He finished the work after his friends left.

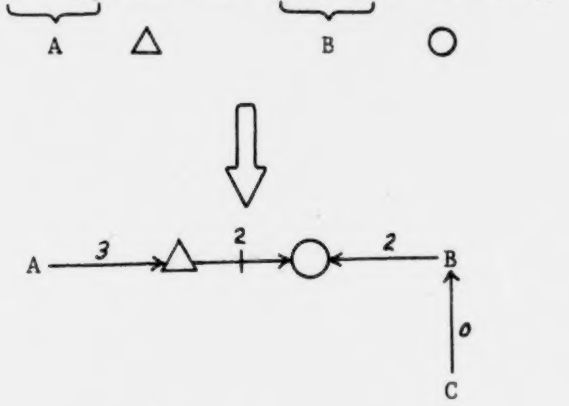



After his friends left he finished the work.
C
A
B
C
1
2
A
1
2
B

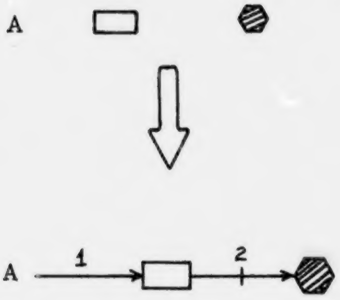
### 4.3.8. Representation of NOMINAL CLAUSEs

A CLAUSE may serve in a NOMINAL position of a PRIMARY CLAUSE. When a CLAUSE serves as an argument of a PRIMARY RELATION in a second CLAUSE, a marked arc is drawn from the PRIMARY RELATION of the PRIMARY CLAUSE to the PRIMARY RELATION of the NOMINAL CLAUSE. The following examples are illustrative of this treatment. (Note that the NOMINAL CLAUSE may consist of just a PRIMARY RELATION).

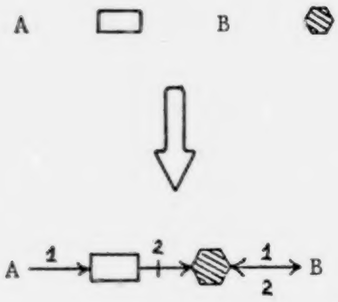
The boy knew that the answer was wrong.



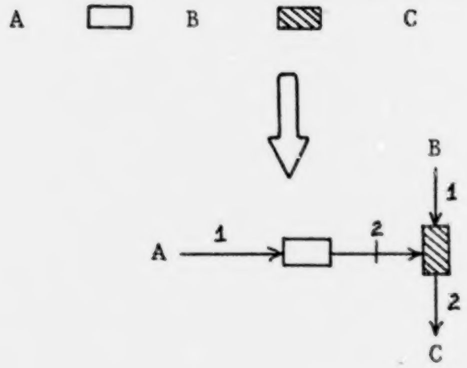
I would like to go.



I would like him to go.

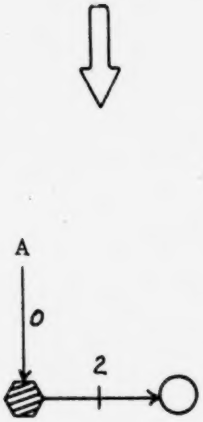


Mary wanted him to mail $\underbrace{\text{the letter}}_{}$.


A
B
C
B
1
A
1
2
2
C

To err is human.

⬣ ○ A

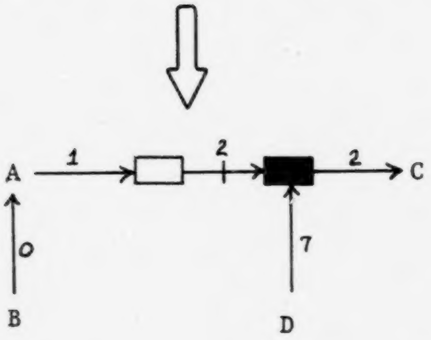


Effort on sentence classification has been devoted to finding

A B ▭ ■

algorithms for implementation.

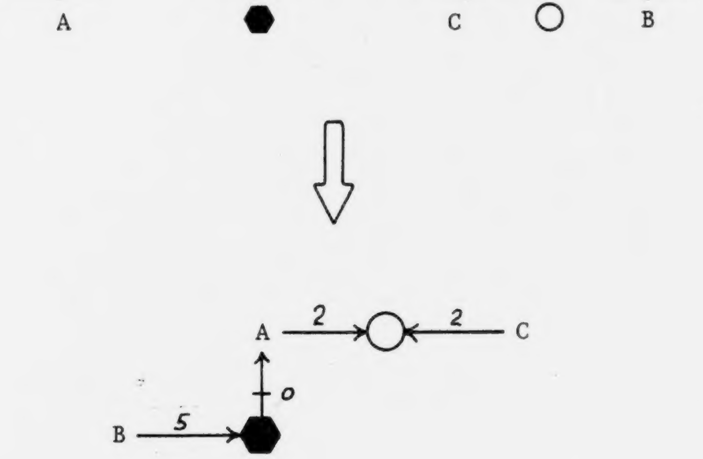
C D



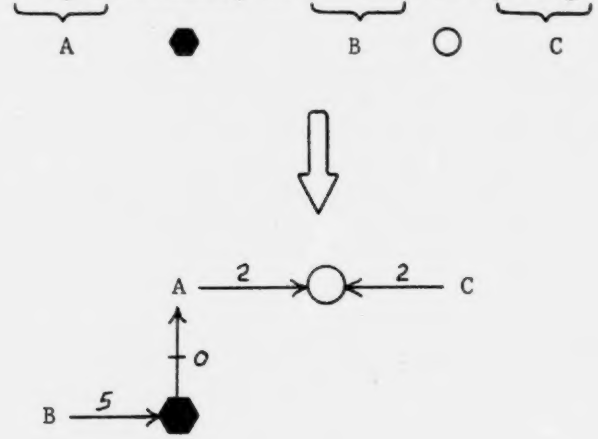
### 4.3.9. Representation of ADJECTIVAL CLAUSEs

ADJECTIVAL CLAUSEs are connected to a NOMINAL PHRASE by a marked arc. The arc is drawn from the PRIMARY RELATION of the ADJECTIVAL CLAUSE to the NOMINAL PHRASE.

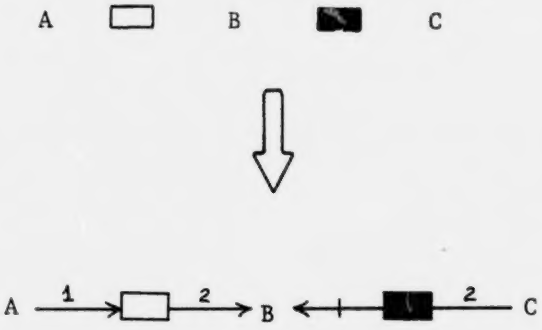
The girl who is standing in the hall is my daughter.



The girl standing in the hall is my daughter.


A
B
C
A
2
2
C
0
B
5

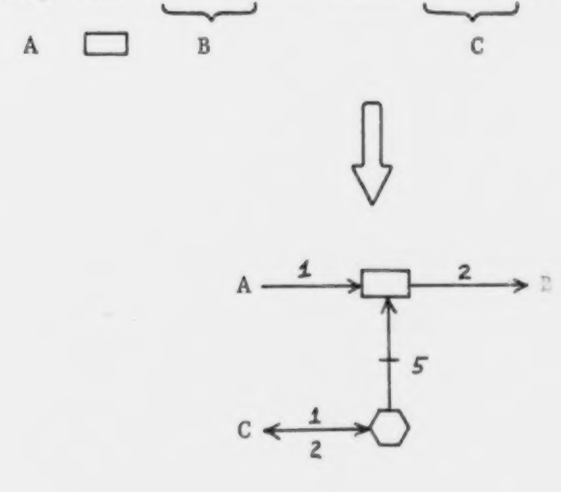
Mary disliked John throwing rocks.



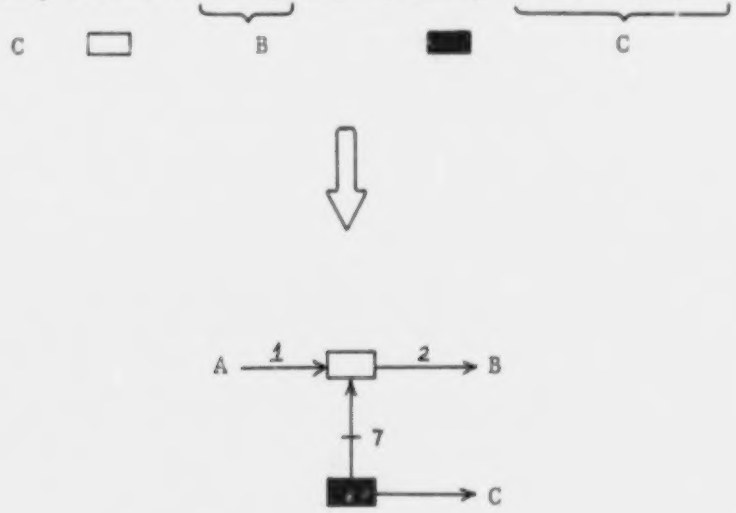
### 4.3.10. Representation of ADVERBIAL CLAUSEs

ADVERBIAL CLAUSEs are depicted in a manner similar to that for NOMINAL and ADJECTIVAL CLAUSEs. A marked arc is drawn from the PRIMARY RELATION of the ADVERBIAL CLAUSE to the PRIMARY RELATION which it modifies. Examples of adverbial clauses are:

They rowed the boat to where the birds were circling.



They tested the compounds by using the new equipment.



These examples serve to illustrate the way in which SENTENCEs in English may be transformed into graphical representation. Such representations are susceptible of production by computer program. Although the programs for doing so have not been written, all of the necessary data to carry out the transformation from linear sequences to graphical representations are made available by the programs developed in this research.

## 5. Summary

In this chapter, it has been suggested that the proposed graphical representation of SENTENCEs provide a strong basis for the derivation of indexes. The representations preserve and explicate the NAMEs and RELATIONs in a SENTENCE and make it possible to extract NAMEs at various levels of complexity for various purposes. For instance, keyword indexes, KWIC indexes, articulated indexes, and so on can still be derived from the graphical representation, but more complex aggregates can also be retrieved. Such graphs make it possible for the first time to do what the chemist calls a "substructure search", that is, to isolate component parts of a structure related to the searcher in some meaningful (to him) way.

Much of the work in this chapter has gone on in parallel with that carried out by Strong (22), and the interested reader may wish to consult that work for additional information on graphical representations of text.

## References

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8. R. Fugmann, *et al*., *op*. *cit*., 589-595.

9. B. C. Landry, "A Theory of Indexing: Indexing Theory as a Model for Information Storage and Retrieval," Computer and Information Science Research Center, CISRC-TR-71-13, The Ohio State University, 1971, p.53.

10. *ibid*., p.42.

11. D. G. Hayes, "Dependency Theory: A Formalism and Some Observations," *Language* 40 (4), 511-525 (1964).

12. Fugmann, *et al*., *op*. *cit*., 589-595.

13. G. Salton, "Manipulation of Trees in Information Retrieval *Communications of the ACM*, 05 (02), 103-144 (1962).

14. Hayes, *op. cit.*, 511-525.

15. Salton, *op. cit.*, p. 138.

16. Fugmann, *et al.*, *op. cit.*, p. 592.

17. R. C. Shank and L. Tesler, "A Conceptual Dependency Parser for Natural Language," *Statistic Methods in Linguistics* 06, 31-51 (1970).

18. Fugmann, *et al.*, *op. cit.*, p. 594.

19. J. J. Katz and J. A. Fodor, "The Structure of a Semantic Theory," *Language* 39 (02), 1963.

20. W. Plath, "Automatic Sentence Diagramming 1961 International Conference on Machine Translation of Languages and Applied Language Analysis, 1 (13), 176-208 (1961).

21. L. Tesnieré, *Elements de Syntaxe Structural*, Paris, Klenchsuck, quoted by R. Pages: in "Relational Aspects of Conceptualization in Message Analysis, from J. M. Perreault, "Proceedings of the International Symposium on Relational Factors in Classification *Information Storage and Retrieval*, 3 (4), 177-410 (1967).

# CHAPTER VII. CONCLUSIONS AND DIRECTIONS FOR FUTURE RESEARCH

## 1. Conclusions

One of Murphy's laws has it that whatever one wishes to do he must always do something else first. So it has been with this research. The general aim of the work has been toward automated indexing. But before that could be done a great deal of work in computational linguistics had to be done first. Thus programs have been developed which provide for the analysis of English text on several levels. These programs are all efficient (at least in relation to any earlier programs written for the same purposes) and they are effective. Furthermore they have all been related within a theoretical framework of language and are therefore logically consistent. Perhaps the most important observation to be made is that all the procedures are more nearly free of semantic inferences than any other similar programs so far developed. And the fact that the case grammar program described in Chapter V is the first such program to be developed is also a significant achievement.

But all of the language analysis procedures are only a means to an end. That end has not been reached, but the structural representations proposed in Chapter VI are close to the desired goal, namely the automatic generation of a relationally rich base from which better indexes might be derived. Further comment on that point is, unfortunately, idle speculation now.

Some significant progress has been made in language analysis by computer, and it may be hoped that these results will lead to new, improved indexing procedures in the near future.

## 2. Directions for Future Research

Several lines of investigation suggest themselves. Refinement of the language analysis procedures is one of these, one which is already underway (Chapter IV). Refinements may take two directions. One is to improve the efficiency of the programs by redesigning them or by recoding them in assembler language, for instance. The second is to improve the accuracy of the output of this procedure by adding or modifying rules and by further refining the dictionaries.

A second line of investigation concerns the completion of the definition and implementation of the graphical-representation procedures. This area too is under active study, but much needs to be done.

A third area of study is that dealing with more of the interpretational aspects of language. Thus it may be important not only to know how words relate to one another within a body of text, but also how they are related to other bodies of text or to "real-world" referents. For information retrieval systems this is an important question.

There are many other possibilities. The last to be mentioned is automatic abstracting. It may be expected that improved abstracting procedures could be developed using data derived by the language analysis procedures. The precise way in which linguistic data would be used in automatic abstracting remains to be determined.

# APPENDIX A

# APPENDIX A. A LISTING OF DICTIONARY ELEMENTS AND THEIR FREQUENCY

The elements contained within the dictionary were chosen from the Brown University statistical analysis of a corpus of a million words (1). Elements were chosen on the basis of their frequency of occurrence. The extended dictionary consists of the entire listing presented in this Appendix. The basic dictionary consists of all the elements except for VRBs and ADVs.

ADV

| Element | Frequency |
|---|---|
| only | 1747 |
| even | 1171 |
| also | 1069 |
| just | 872 |
| too | 832 |
| still | 782 |
| here | 750 |
| again | 578 |
| once | 499 |
| always | 458 |
| away | 456 |
| less | 438 |
| almost | 432 |
| later | 397 |
| often | 368 |
| early | 366 |
| perhaps | 307 |
| today | 284 |
| really | 275 |
| already | 273 |
| together | 267 |
| probably | 261 |
| ago | 246 |
| sometimes | 221 |
| further | 218 |
| usually | 206 |
| soon | 199 |
| near | 198 |
| alone | 195 |
| finally | 191 |
| farther | 183 |
| simply | 170 |
| actually | 166 |
| especially | 160 |
| certainly | 143 |
| ready | 143 |
| directly | 141 |
| particularly | 146 |
| likely | 151 |
| suddenly | 153 |
| nearly | 141 |
| merely | 135 |
| generally | 132 |
| clearly | 128 |

| Element | Frequency |
|---|---|
| somewhat | 127 |
| apparently | 125 |
| immediately | 123 |
| recently | 123 |
| daily | 122 |
| forward | 115 |
| slowly | 115 |
| obviously | 114 |
| completely | 110 |
| ahead | 109 |
| easily | 106 |
| hardly | 106 |
| exactly | 103 |

AUX

| Element | Frequency |
|---|---|
| is | 10099 |
| was | 9816 |
| be | 6377 |
| had | 5133 |
| are | 4393 |
| have | 3941 |
| were | 3284 |
| been | 2472 |
| has | 2439 |
| being | 712 |
| it's | 302 |
| having | 279 |
| I'm | 268 |
| am | 228 |
| that's* | 186 |
| can't | 796 |
| wasn't | 154 |
| there's | 109 |
| you're | 151 |
| hadn't | 99 |
| he'd | 98 |
| isn't | 77 |
| she'd | 67 |
| one's | 65 |
| they're | 65 |
| we're | 58 |

MOD

| Element | Frequency |
|---|---|
| would | 2714 |
| will | 2244 |
| can | 1772 |
| could | 1599 |
| may | 1400 |
| must | 1013 |
| should | 888 |
| might | 672 |
| shall | 267 |
| cannot | 258 |
| I'll | 181 |
| couldn't | 175 |
| wouldn't | 129 |
| won't | 105 |
| we'll | 64 |
| he'll | |
| she'll | |

AJN

| Element | Frequency |
|---|---|
| do | 1363 |
| did | 1044 |
| don't | 489 |
| does | 485 |
| didn't | 401 |
| doesn't | 87 |
| got | 482 |
| get | 750 |
| let | 384 |

CCN

| Element | Frequency |
|---|---|
| and | 28852 |
| but | 4381 |
| or | 4207 |
| nor | 195 |
| not | |

SCN

| Element | Frequency |
|---|---|
| if | 2199 |
| than | 1789 |
| then | 1377 |
| like | 1290 |
| since | 628 |
| however | 552 |
| though | 442 |
| yet | 419 |
| although | 319 |
| thus | 312 |
| whether | 286 |
| therefore | 205 |
| unless | 101 |

DTR

| Element | Frequency |
|---|---|
| the | 69971 |
| a | 23237 |
| his | 6997 |
| an | 3747 |
| their | 2670 |
| its | 1858 |
| my | 1319 |
| our | 1252 |
| your | 923 |
| 1 | 496 |
| every | 491 |
| 2 | 450 |
| 3 | 282 |
| 4 | 196 |
| third | 193 |
| 10 | 143 |
| 5 | 134 |
| 6 | 113 |
| 15 | 109 |
| 30 | 106 |
| 8 | 104 |
| 12 | 98 |

DTR/PRN

| Element | Frequency |
|---|---|
| this | 5146 |
| one | 3292 |
| her | 3037 |
| all | 3001 |
| more | 2216 |
| other | 1702 |
| some | 1617 |
| these | 1573 |
| two | 1412 |
| first | 1360 |
| any | 1345 |
| most | 1160 |
| many | 1030 |
| much | 937 |
| each | 877 |
| those | 850 |
| own* | 772 |
| both | 730 |
| same | 686 |
| another | 683 |
| three | 610 |
| few | 601 |
| enough | 436 |
| several | 377 |
| second | 373 |
| four | 359 |
| kind | 313 |
| five | 286 |
| six | 220 |
| million | 204 |
| hundred | 171 |
| ten | 165 |
| neither | 141 |
| ones | 116 |
| eight | 104 |
| whole | 309 |
| either | 284 |

INT

| Element | Frequency |
|---|---|
| very | 796 |
| rather | 373 |
| quite | 281 |

PRP

| Element | Frequency |
|---|---|
| of | 36411 |
| to | 26149 |
| in | 21341 |
| for | 9489 |
| with | 7289 |
| on | 6742 |
| at | 5378 |
| by | 5305 |
| from | 4369 |
| out | 2096 |
| up | 1895 |
| over | 1236 |
| after | 1070 |
| before | 1016 |
| through | 969 |
| down | 895 |
| between | 730 |
| under | 707 |
| off | 639 |
| during | 585 |
| without | 583 |
| around | 561 |
| upon | 495 |
| until | 461 |
| toward | 386 |
| among | 370 |
| within | 359 |
| along | 355 |
| above | 296 |
| across | 282 |
| outside | 210 |
| except | 181 |
| beyond | 175 |
| inside | 174 |
| instead | 173 |
| throughout | 141 |
| dispite | 104 |
| about | 1815 |
| into | 1791 |
| below | 145 |
| according | 139 |
| behind | 258 |

$\underline{PRN_1}$

| Element | Frequency |
|---|---|
| he | 9543 |
| it | 8756 |
| I | 5173 |
| they | 3618 |
| you | 3286 |
| she | 2859 |
| we | 2653 |
| him | 2619 |
| them | 1789 |
| me | 1181 |
| us | 612 |
| things | 368 |
| least | 343 |
| thing | 333 |
| others | 323 |
| anyone | 140 |
| none | 108 |

$\underline{PRN_2}$

| Element | Frequency |
|---|---|
| something | 450 |
| nothing | 412 |
| anything | 280 |
| everything | 185 |

$\underline{PRN_3}$

| Element | Frequency |
|---|---|
| himself | 603 |
| itself | 304 |
| themselves | 270 |
| myself | 129 |
| herself | 125 |

REL

| Element | Frequency |
|---|---|
| which | 3562 |
| who | 2252 |
| what | 1908 |
| whose | 252 |
| whom | 146 |
| when | 2231 |
| where | 938 |
| how | 834 |
| while | 680 |
| why | 404 |
| whatever | 112 |

VRB

| Element | Frequency |
|---|---|
| said | 1961 |
| made | 1125 |
| make | 794 |
| see | 772 |
| know | 683 |
| come | 630 |
| go | 625 |
| came | 622 |
| take | 611 |
| found | 536 |
| went | 507 |
| say | 504 |
| put | 437 |
| think | 433 |
| took | 426 |
| set | 414 |
| told | 413 |
| find | 399 |
| going | 399 |
| look | 399 |
| knew | 395 |
| give | 391 |
| given | 377 |
| become | 361 |
| saw | 352 |
| want | 329 |
| done | 320 |
| began | 312 |

| Element | Frequency |
|---|---|
| gave | 285 |
| taken | 281 |
| seen | 279 |
| tell | 268 |
| held | 264 |
| keep | 264 |
| seems | 258 |
| brought | 253 |
| heard | 247 |
| became | 246 |
| known | 245 |
| seem | 229 |
| provide | 216 |
| believe | 200 |
| says | 200 |
| gone | 195 |
| kept | 186 |
| wrote | 181 |
| lead | 173 |
| makes | 172 |
| tried | 170 |
| shown | 166 |
| bring | 158 |
| written | 514 |
| hear | 153 |
| sat | 150 |
| meet | 148 |
| paid | 145 |
| sent | 145 |
| showed | 141 |
| remember | 138 |
| comes | 137 |
| understand | 132 |
| ran | 134 |
| led | 132 |
| met | 132 |
| ask | 128 |
| consider | 126 |
| appear | 118 |
| born | 113 |
| include | 113 |
| gives | 112 |
| speak | 110 |
| expect | 108 |
| continue | 107 |
| determine | 107 |
| serve | 107 |
| stress | 107 |
| applied | 106 |
| closed | 106 |
| reach | 106 |
| write | 105 |
| married | 105 |
| remained | 105 |
| covered | 104 |
| played | 104 |
| spent | 104 |
| built | 103 |
| becomes | 102 |
| related | 102 |
| rise | 102 |
| meant | 100 |

# APPENDIX B

## References

1. H. Kucera and W. R. Francis, Computational Analysis of Present-Day American English, Brown University, Providence, R. I., 1967.

# APPENDIX B. A LISTING OF THE SOURCE DOCUMENTS FOR THE TESTING OF COMPUTER PROGRAMS.

The documents are:

"The Need for a More Precise Definition of 'Algorithm'"

*The Old Man and the Sea*

"The Clavichord and How to Play It"

THE NEED FOR A MORE PRECISE DEFINITION OF "ALGORITHM". #B. A. TRAKHTENBROT, ALGORITHMS AND AUTOMATIC COMPUTING MACHINES, 52-57 (1963).# OUR PREVIOUS DISCUSSION SHOWS THE STRONG CONNECTION WHICH EXISTS BETWEEN ALGORITHMS AND AUTOMATIC COMPUTING MACHINES. OBVIOUSLY, ANY PROCESS WHICH CAN BE PERFORMED BY A MACHINE CAN BE WRITTEN AS AN ALGORITHM. CONVERSELY, ALL ALGORITHMS WHICH HAVE SO FAR BEEN CONSTRUCTED, AS WELL AS THOSE WHICH MAY BE EXPECTED IN THE PRESENT STATE OF SCIENCE, CAN IN PRINCIPLE BE PERFORMED BY MACHINE. THE LAST STATEMENT REQUIRES SOME CLARIFICATION. AS WE HAVE ALREADY SEEN, THE ACTUAL APPLICATION OF AN ALGORITHM MAY TURN OUT TO BE VERY LENGTHY, AND THE JOB OF RECORDING ALL OF THE INFORMATION INVOLVED MAY BE ENORMOUS. ON THE OTHER HAND, THE MEMORY UNITS OF MACHINES HAVE A LIMITED CAPACITY (SINCE THE NUMBER OF MEMORY CELLS IS FINITE AND THE CAPACITY OF EACH CELL IS LIMITED). THEREFORE, IT MAY TURN OUT TO BE IMPOSSIBLE TO EXECUTE AN ALGORITHM UNDER EXISTING CONDITIONS. THIS CAN BE ILLUSTRATED BY THE EUCLIDEAN ALGORITHM. THE VERY SIMPLE PROBLEM OF FINDING THE GREATEST COMMON DIVISOR OF TWO NUMBERS CANNOT BE SOLVED BY HAND IF IT REQUIRES MORE PAPER AND INK THAN IS AVAILABLE. SIMILARLY, A PROBLEM WILL NOT BE SOLVABLE BY MACHINE IF IT REQUIRES MORE MEMORY SPACE THAN THERE IS IN THE MACHINE. IN SUCH CASES WE SAY THAT AN ALGORITHM IS POTENTIALLY REALIZABLE IF IT LEADS TO THE REQUIRED RESULT IN A FINITE NUMBER OF STEPS (EVEN THOUGH THIS NUMBER MAY BE VERY LARGE). IN OTHER WORDS, IT WOULD BE POSSIBLE TO USE THE ALGORITHM IN A MACHINE WHICH HAD AN UNLIMITED MEMORY CAPACITY. THE CONNECTION BETWEEN THE IDEA OF AN ALGORITHM AND THE IDEA OF AN AUTOMATIC MACHINE WITH A MEMORY OF INIFNITE CAPACITY LEADS TO A CLEAR UNDERSTANDING OF THE NATURE OF EACH. HOWEVER, FOR ALL OF OUR EMPHASIS ON THEIR CONNECTION, WE STILL HAVE NOT DEFINED EITHER OF THESE IDEAS PRECISELY AN EXACT MATHEMATICAL DEFINITON OF THE NOTION OF ALGORITHMS (AND, AT THE SAME TIME, OF AUTOMATIC COMPUTING MACHINES) WAS NOT PRODUCED UNTIL THE 1930'S. WHY, THROUGH THE COURSE OF MANY CENTURIES, HAVE MATHEMATICIANS TOLERATED WITHOUT ANY PARTICULAR QUALMS AN UNCLEAR NOTION OF ALGORITHMS? WHY IS IT THAT ONLY RECENTLY HAS AN ACUTE NEED FOR A DEFINITON SUFFICIENTLY EXACT FOR MATHEMATICAL DISCUSSION ARISEN?¬ EARLIER, THE TERM "ALGORITHM" OCCURRED IN MATHEMATICS ONLY IN CONNECTION WITH CONCRETE ALGORITHMS, WHERE AN ASSERTION OF THE EXISTENCE OF AN ALGORITHM WAS ALWAYS ACCOMPANIED BY A DESCRIPTION OF SUCH AN ALGORITHM. UNDER THESE CONDITIONS IT WAS NECESSARY TO SHOW ONLY THAT THE SYSTEM OF FORMAL INSTRUCTION WHEN APPLIED TO ANY DATA IN FACT LED AUTOMATICALLY TO THE DESIRED RESULT. THUS, THE NEED FOR A PR-CISE DEFINITION OF THE NOTION OF ALGORITHM NEVER AROSE, ALTHOUGH EVERY MATHEMATICIAN HAD A WORKING IDEA OF WHAT THE TERM MEANT. HOWEVER, IN THE COURSE OF MATHEMATICAL PROGRESS, FACTS BEGAN TO ACCUMULATE WHICH RADICALLY CHANGED THE SITUATION. THE MOTIVE FORCE WAS THE NATURAL DESIRE OF MATHEMATICIANS TO CONSTRUCT INCREASINGLY POWERFUL ALGORITHMS FOR SOLVING INCREASINGLY GENERAL TYPES OF PROBLEMS. RECALL THE ALGORITHM FOR FINDING SQUARE ROOTS. WE MIGHT WISH TO GENERALIZE THIS PROBLEM: TO CONSTRUCT AN ALGORITHM FOR FINDING THE ROOT OF ANY DEGREE OF ANY GIVEN NUMBER. IT IS NATURAL TO EXPECT THAT SUCH AN ALGORITHM WILL BE MORE DIFFICULT TO CONSTRUCT, BUT THE PROSPECT OF HAVING IT IS ATTRACTIVE. WE MAY GO EVEN FURTHER. FINDING THE NTH ROOT OF A NUMBER A MEANS SOLVING THE EQUATION X**N-A=0 (FINDING THE ROOTS OF THE EQUATION). WE CAN FORMULATE THE STILL MORE GENERAL PROBLEM: CONSTRUCT AN ALGORITHM FOR FINDING ALL ROOTS OF ANY EQUATION OF THE FORM A(N)X**N+A(N-1)X**N-1+...+A(1)X+A(0)=0, WHERE N IS AN ARBITRARY POSITIVE INTEGER. THE CONSTRUCTION OF SUCH AN ALGORITHM IS STILL MORE DIFFICULT. IN FACT, THE BASIC CONTENT OF THE THEORY OF EQUATION AMOUNTS TO THE CONSTRUCTION OF JUST THIS ALGORITHM; IT IS OF THE GREATEST IMPORTANCE. THE EXAMPLES GIVEN SHOW THE NATURAL STRIVING OF MATHEMATICIANS TO FIND INCREASINGLY POWERFUL ALGORITHMS TO SOLVE INCREASINGLY GENERAL TYPES OF PROBLEMS. OF COURSE, THE EXAMPLE OF SOLVING ALL EQUATIONS OF THE FORM ABOVE DOES NOT REPRESENT THE LIMIT TO WHICH ONE MIGHT GO. IF WE WANT TO PUSH THIS DESIRE FOR INCREASINGLY GENERAL ALGORITHMS TO THE EXTREME WE MUST INEVITABLY CONSIDER THIS PROBLEM: CONSTRUCT AN ALGORITHM FOR SOLVING ANY MATHEMATICAL PROBLEM. THIS IS A PROBLEM SO GENERAL THAT IT MIGHT BE CONSIDERED AN INSOLENT CHALLENGE TO MATHEMATICS AS A WHOLE. BESIDES THIS, IT CAN BE CRITICIZED ON THE GROUNDS THAT IT IS NOT CLEAR WHAT IS MEANT BY "ANY MATHEMATICAL PROBLEM." AT THE SAME TIME, THE GREAT ALLURE OF SOLVING SUCH A PROBLEM CANNOT BE DOUBTED. THIS PROBLEM HAS ITS OWN HISTORY. THE GREAT GERMAN MATHEMATICIAN AND PHILOSOPHER LEIBNIZ (1646-1716) DREAMED OF AN ALL-INCLUSIVE METHOD FOR SOLVING ANY PROBLEM. ALTHOUGH HE WAS UNABLE TO FIND IT, LEIBNIZ STILL THOUGHT THAT THE TIME WO

ULD COME WHEN IT WOULD BE DISCOVERED, AND THAT ANY ARGUMENT AMONG MATHEMATICIANS COULD THEN AUTOMATICALLY BE SETTLED WITH PENCIL AND PAPER. LATER, THE PROBLEM RECEIVED SOME REFINEMENT IN THE FORM OF ONE OF THE MOST FAMOUS PROBLEMS OF MATHEMATICAL LOGIC, THE DEDUCIBILITY PROBLEM. SINCE WE DO NOT HAVE THE ROOM FOR A COMPLETE TREATMENT OF THE PROBLEM, WE SHALL MERELY SKETCH ITS GENERAL OUTLINES. AS IS WELL KNOWN, THE AXIOMATIC METHOD IN MATHEMATICS CONSISTS IN DERIVING ALL THEOREMS IN A GIVEN THEORY BY FORMAL LOGICAL STEPS FROM CERTAIN AXIOMS WHICH ARE ACCEPTED WITHOUT PROOF. THE FIRST OF ALL AXIOMATIC THEORIES WAS GEOMETRY, BUT IN MODERN MATHEMATICS ALMOST ALL THEORIES ARE CONSTRUCTED AXIOMATICALLY. MATHEMATICAL LOGIC EMPLOYS A SPECIAL "LANGUAGE OF FORMULAS" THAT ENABLES US TO WRITE ANY PROPOSITION OF A MATHEMATICAL THEORY AS A UNIQUELY DETERMINED FORMULA. IN THE TERMINOLOGY WHICH WE USED EARLIER FOR AN ASSOCIATIVE CALCULUS, WE MAY SAY THAT SUCH A FORMULA IS A WORD IN A SPECIAL ALPHABET CONTAINING SYMBOLS TO DENOTE LOGICAL OPERATIONS SUCH AS NEGATION, CONJUNCTION, AND IMPLICATION, AS WELL AS THE USUAL MATHEMATICAL SYMBOLS, SUCH AS PARENTHESES, AND LETTERS TO DENOTE FUNCTIONS AND VARIABLES. HOWEVER, THE CHIEF SIMILARITY TO AN ASSOCIATIVE CALCULUS CONSISTS IN THE POSSIBILITY OF WRITING THE LOGICAL DERIVATION OF A STATEMENT S FROM A PREMISE R IN THE FORM OF FORMAL TRANSFORMATION OF WORDS, VERY SIMILAR TO THE ADMISSIBLE SUBSTITUTIONS IN AN ASSOCIATIVE CALCULUS. THIS ALLOWS US TO SPEAK OF A LOGICAL CALCULUS, WITH A SYSTEM OF ADMISSIBLE TRANSFORMATIONS REPRESENTING ELEMENTARY ACTS OF LOGICAL DEDUCTION, FROM WHICH ANY LOGICAL INFERENCE, OF ARBITRARY COMPLEXITY, MAY BE BUILT. AN EXAMPLE OF SUCH AN ADMISSIBLE TRANSFORMATION IS THE ELIMINATION OF TWO CONSECUTIVE NEGATIONS IN A FORMULA; THUS, "NOT UNPROVED" MAY BE TRANSFORMED INTO "PROVED." THE QUESTION OF THE LOGICAL DEDUCIBILITY OF THE PROPOSITION S FROM THE PREMISE R IN A LOGICAL CALCULUS BECOMES THE QUESTION OF THE EXISTENCE OF A DEDUCTIVE CHAIN LEADING FROM THE WORD REPRESENTING R TO THE WORD REPRESENTING S. THE DEDUCIBILITY PROBLEM MAY NOW BE FORMULATED AS FOLLOWS: FOR ANY TWO WORDS (FORMULAS) R AND S IN A LOGICAL CALCULUS, DETERMINE WHETHER OR NOT THERE EXISTS A DEDUCTIVE CHAIN FROM R TO S. THE SOLUTION IS SUPPOSED TO BE AN ALGORITHM FOR SOLVING ANY PROBLEM OF THIS TYPE (ANY R AND S).¬ SUCH AN ALGORITHM WOULD GIVE A GENERAL METHOD FOR SOLVING PROBLEMS IN ALL MATHEMATICAL THEORIES WHICH ARE CONSTRUCTED AXIOMATICALLY (OR RATHER, IN ALL FINITELY AXIOMATIZABLE THEORIES). THE VALIDITY OF ANY STATEMENT S IN SUCH A THEORY MERELY MEANS THAT IT CAN BE DEDUCED FROM THE SYSTEM OF AXIOMS, OR WHAT IS THE SAME THING, THAT IT CAN BE DEDUCED FROM THE STATEMENT R WHICH ASSERTS THAT ALL THE AXIOMS HOLD. THEN THE APPLICATION OF THE ALGORITHM WOULD DETERMINE WHETHER OR NOT THE PROPOSITION S WERE VALID. MOREOVER, IF THE PROPOSITION S WERE VALID, THEN WE COULD FIND A CORRESPONDING DEDUCTIVE CHAIN OF INFERENCE WHICH WOULD PROVE THE PROPOSITION. THE PROPOSED ALGORITHMS WOULD IN FACT BE A SINGLE EFFECTIVE METHOD FOR SOLVING ALMOST ALL OF THE MATHEMATICAL PROBLEMS WHICH HAVE BEEN FORMULATED AND REMAIN UNSOLVED TO THIS DAY. THAT IS WHY CONSTRUCTING SUCH AN "ALL-INCLUSIVE ALGORITHM" AND AN "OMNIPOTENT MACHINE"¬ TO MATCH IT IS SO APPEALING A PROSPECT AND AT THE SAME TIME SO DIFFICULT. FINDING SUCH AN ALGORITHM HAVE REMAINED INSURMOUNTABLE. FURTHERMORE, SIMILAR DIFFICULTIES WERE SOON ENCOUNTERED IN TRYING TO FIND ALGORITHMS FOR CERTAIN PROBLEMS OF A FAR LESS GENERAL NATURE. AMONG THESE WERE HILBERT'S PROBLEM ON DIOPHANNTINE EQUATIONS, AS WELL AS OTHERS WHICH WILL BE DISCUSSED BELOW. AS A RESULT OF MANY FRUITLESS ATTEMPTS TO CONSTRUCT SUCH ALGORITHMS, IT BECAME CLEAR THAT THE DIFFICULTIES INVOLVED ARE BASIC, AND IT CAME TO BE SUSPECTED THAT IT IS NOT POSSIBLE TO CONSTRUCT AN ALGORITHM FOR EVERY CLASS OF PROBLEMS. THE ASSERTION THAT A CERTAIN CLASS OF PROBLEMS CANNOT BE SOLVED ALGORITHMICALLY IS NOT SIMPLY A STATEMENT THAT NO ALGORITHM HAS YET BEEN DISCOVERED. IT IS THE STATEMENT THAT SUCH AN ALGORITHM IN FACT CAN NEVER BE DISCOVERED, IN OTHER WORDS, THAT NO SUCH AN ALGORITHM CAN EXIST. THIS ASSERTION MUST BE BASED ON SOME SORT OF MATHEMATICAL PROOF; HOWEVER, SUCH A PROOF MAKES NO SENSE UNTIL WE HAVE A PRECISE DEFINITION OF "ALGORITHM", SINCE UNTIL THEN IT IS NOT CLEAR WHAT IT IS WE ARE TRYING TO PROVE IMPOSSIBLE. IT IS USEFUL TO REMEMBER AT THIS POINT THAT IN THE HISTORY OF MATHEMATICS THERE HAVE BEEN OTHER PROBLEMS FOR WHICH SOLUTIONS HAD BEEN SOUGHT IN VAIN FOR A LONG TIME, AND FOR WHICH IT WAS ONLY LATER PROVED THAT SOLUTIONS COULD NOT BE OBTAINED. EXAMPLES ARE THE PROBLEM OF TRISECTING THE ANGLE AND THE PROBLEM OF SOLVING THE GENERAL FIFTH DEGREE EQUATION BY RADICALS. ¬ A METHOD OF BISECTING AN ANGLE USING COMPASS AND STRAIGHTEDGE IS KNOWN TO EVERY SCHOOLBOY. THE ANCIENT GREEKS TRIED TO SOLVE THE PROBLEM OF TRISECTING AN ANG

LE USING COMPASS AND STRAIGHTEDGE. IT WAS LATER PROVED THAT TRISECTION OF AN ARBITRARY ANGLE BY SUCH MEANS IS IMPOSSIBLE. IT IS ALSO WELL KNOWN THAT THE SOLUTION OF A QUADRATIC EQUATION CAN BE WRITTEN IN TERMS OF THE COEFFICIENTS BY MEANS OF A FORMULA WHICH EMPLOYS THE SIGNS FOR THE ARITHMETIC OPERATIONS AND THE RADICAL SIGN. THERE ARE ALSO FORMULAS IN RADICALS, WHICH ARE EXTREMELY COMPLICATED, FOR THIRD AND FOURTH DEGREE EQUATIONS. A SEARCH FOR SIMILAR SOLUTIONS BY RADICALS FOR EQUATIONS OF DEGREE HIGHER THAN FOUR WAS CARRIED ON UNSUCCESSFULLY UNTIL THE BEGINNING OF THE NINETEENTH CENTURY, WHEN THE FOLLOWING REMARKABLE RESULT WAS FINALLY ESTABLISHED. FOR ANY N GREATER THAN OR EQUAL TO FIVE, IT IS IMPOSSIBLE TO EXPRESS THE ROOTS OF THE GENERAL NTH DEGREE EQUATION IN TERMS OF ITS COEFFICIENTS BY MEANS OF THE ARITHMETIC OPERATIONS AND THE OPERATION OF EXTRACTING ROOTS. IN BOTH THESE CASES THE PROOF OF IMPOSSIBILITY TURNED OUT TO BE FEASIBLE ONLY AFTER THERE WERE PRECISE DEFINITIONS TO ANSWER THE QUESTIONS "WHAT IS MEANT BY A COMPASS AND STRAIGHTEDGE CONSTRUCTION?" AND "WHAT IS MEANT BY SOLVING AN EQUATION IN RADICALS?" NOTE THAT THESE TWO DEFINITIONS GAVE A MORE PRECISE MEANING TO CERTAIN SPECIAL ALGORITHMS, NAMELY, THE ALGORITHM FOR SOLVING AN EQUATION IN RADICALS (NOT FOR THE SOLUTION OF EQUATIONS IN GENERAL) AND THE ALGORITHM FOR TRISECTING AN ANGLE WITH COMPASS AND STRAIGHTEDGE (NOT FOR TRISECTING BY ARBITRARY DEVICES). UNTIL RECENTLY, THERE WAS NO PRECISE DEFINITION OF THE CONCEPT "ALGORITHM" AND THEREFORE THE CONSTRUCTION OF SUCH A DEFINITION CAME TO BE ONE OF THE MAJOR PROBLEMS OF MODERN MATHEMATICS. IT IS VERY IMPORTANT TO POINT OUT THAT THE FORMULATION OF A DEFINITION OF "ALGORITHM" (OR OF ANY OTHER MATHEMATICAL DEFINITION) MUST BE CONSIDERED NOT MERELY AN ARBITRARY AGREEMENT AMONG MATHEMATICIANS AS TO WHAT THE MEANING OF THE WORD "ALGORITHM" SHOULD BE. THE DEFINITION HAS TO REFLECT ACCURATELY THE SUBSTANCE OF THOSE IDEAS WHICH ARE ACTUALLY HELD, HOWEVER VAGUELY, AND WHICH HAVE ALREADY BEEN ILLUSTRATED BY MANY EXAMPLES.- WITH THIS AIM, A SERIES OF INVESTIGATIONS WAS UNDERTAKEN BEGINNING IN THE 1930'S FOR CHARACTERIZING ALL THE METHODS WHICH WERE ACTUALLY USED IN CONSTRUCTING ALGORITHMS. THE PROBLEM WAS TO FORMULATE A DEFINITION OF THE CONCEPT OF ALGORITHM WHICH WOULD BE COMPLETE NOT ONLY IN FORM, BUT, MORE IMPORTANT, IN SUBSTANCE. VARIOUS WORKERS PROCEEDED FROM DIFFERENT LOGICAL STARTING POINTS, AND BECAUSE OF THIS, SEVERAL DEFINITIONS WERE PROPOSED. HOWEVER, IT TURNED OUT THAT ALL OF THESE WERE EQUIVALENT, AND THEY DEFINED THE SAME CONCEPT; THIS WAS THE MODERN DEFINITION OF ALGORITHM. THE FACT ALL OF THESE APPARENTLY DIFFERENT DEFINITIONS WERE REALLY ESSENTIALLY THE SAME IS QUITE SIGNIFICANT; IT INDICATES THAT WE HAVE A WORTHWHILE DEFINITION. FROM THE POINT OF VIEW OF MACHINE MATHEMATICS, WE ARE ESPECIALLY INTERESTED IN THE FORM OF THE DEFINITION WHICH PROCEEDS FROM A CONSIDERATION OF THE PROCESSES PERFORMABLE BY MACHINES. FOR SUCH A RIGOROUS MATHEMATICAL DEFINITION IT IS NECESSARY TO REPRESENT THE OPERATION OF THE MACHINE IN THE FORM OF SOME STANDARD SCHEME, WHICH HAS AS SIMPLE A LOGICAL STRUCTURE AS POSSIBLE, BUT WHICH IS SUFFICIENTLY PRECISE FOR USE IN MATHEMATICAL INVESTIGATIONS. THIS WAS FIRST DONE BY THE ENGLISH MATHEMATICIAN TURING, WHO PROPOSED A VERY GENERAL BUT VERY SIMPLE CONCEPTION OF A COMPUTING MACHINE. IT SHOULD BE NOTED THAT THE TURING MACHINE WAS FIRST DESCRIBED IN 1937, THAT IS, BEFORE THE CONSTRUCTION OF MODERN COMPUTING MACHINES. TURING PROCEEDED SIMPLY ON THE GENERAL IDEA OF EQUATING THE OPRATION OF A MACHINE TO THE WORK OF A HUMAN CALCULATOR WHO IS FOLLOWING DEFINITE INSTRUCTIONS. OUR PRESENTATION OF HIS IDEAS WILL UTILIZE THE GENERAL IDEAS OF ELECTRONIC MACHINES NOW IN USE.

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THE OLD MAN AND THE SEA BY. HEMINGWAY#
HE WAS AN OLD MAN WHO FISHED ALONE IN A SKIFF IN THE GULF STREAM AND HE HAD GONE
 EIGHTY-FOUR DAYS NOW WITHOUT TAKING A FISH. IN THE FIRST FORTY DAYS A BOY HAD B
EEN WITH HIM. BUT AFTER FORTY DAYS WITHOUT A FISH THE BOY*S PARENTS HAD TOLD HIM
 THAT THE OLD MAN WAS NOW DEFINITELY AND FINALLY SALAO, WHICH IS THE WORST FORM
OF UNLUCKY, AND THE BOY HAD GONE AT THEIR ORDERS IN ANOTHER BOAT WHICH CAUGHT TH
REE GOOD FISH THE FIRST WEEK. IT MADE THE BOY SAD TO SEE THE OLD MAN COME IN EAC
H DAY WITH HIS SKIFF EMPTY AND HE ALWAYS WENT DOWN TO HELP HIM CARRY EITHER THE
 PERMANENT DEFEAT. THE OLD MAN WAS THIN AND GAUNT WITH DEEP WRINKLES IN THE BACK
 OF HIS NECK. THE BROWN BLOTCHES OF THE BENEVOLENT SKIN CANCER THE SUN BRINGS FR
OM ITS REFLECTION ON THE TROPIC SEA WERE ON HIS CHEEKS. THE BLOTCHES RAN WELL DO
WN THE SIDES OF HIS FACE AND HIS HANDS HAD THE DEEP-CREASED SCARS FROM HANDLING
HEAVY FISH ON THE CORDS. BUT NONE OF THESE SCARS WERE FRESH. THEY WERE AS OLD AS
 EROSIONS IN A FISHLESS DESERT. EVERYTHING ABOUT HIM WAS OLD EXCEPT HIS EYES AND
 THEY WERE THE SAME COLOR AS THE SEA AND WERE CHEERFUL AND UNDEFEATED.
SANTIAGO, THE BOY SAID TO HIM AS THEY CLIMBED THE BANK FROM WHERE THE SKIFF WAS
HAULED UP.  I COULD GO WITH YOU AGAIN. WEVE MADE SOME MONEY. THE OLD MAN HAD TAU
GHT THE BOY TO FISH AND THE BOY LOVED HIM.  NO, THE OLD MAN SAID.  YOURE WITH A
LUCKY BOAT.  STAY WITH THEM. BUT REMEMBER HOW YOU WENT EIGHTY-SEVEN DAYS WITHOUT
 FISH AND THEN WE CAUGHT BIG ONES EVERY DAY FOR THREE WEEKS.  I REMEMBER, THE OL
D MAN SAID.  I KNOW YOU DID NOT LEAVE ME BECAUSE YOU DOUBTED. IT WAS PAPA MADE M
E LEAVE. I AM A BOY AND I MUST OBEY HIM. I KNOW, THE OLD MAN SAID. IT IS QUITE N
ORMAL. HE HASNT MUCH FAITH. NO, THE OLD MAN SAID. BUT WE HAVE. HAVENT WE? YES, T
HE BOY SAID. CAN I OFFER YOU A BEER ON THE TERRACE AND THEN WELL TAKE THE STUFF
HOME. WHY NOT? THE OLD MAN SAID. BETWEEN FISHERMEN. THEY SAT ON THE TERRACE AND
MANY OF THE FISHERMEN MADE FUN OF THE OLD MAN AND HE WAS NOT ANGRY. OTHERS, OF T
HE OLDER FISHERMEN, LOOKED AT HIM AND WERE SAD. BUT THEY DID NOT SHOW IT AND THE
Y SPOKE POLITELY ABOUT THE CURRENT AND THE DEPTHS THEY HAD DRIFTED THEIR LINES A
T AND THE STEADY GOOD WEATHER AND OF WHAT THEY HAD SEEN. THE SUCCESSFUL FISHERME
N OF THAT DAY WERE ALREADY IN AND HAD BUTCHERED THEIR MARLIN OUT AND CARRIED THE
M LAID FULL LENGTH ACROSS TWO PLANKS, WITH TWO MEN STAGGERING AT THE END OF EACH
 PLANK, TO THE FISH HOUSE WHERE THEY WAITED FOR THE ICE TRUCK TO CARRY THEM TO T
HE MARKET IN HAVANA. THOSE WHO HAD CAUGHT SHARKS HAD TAKEN THEM TO THE SHARK FAC
TORY ON THE OTHER SIDE OF THE COVE WHERE THEY WERE HOISTED ON A BLOCK AND TACKLE
, THEIR LIVERS REMOVED, THEIR FINS CUT OFF AND THEIR HIDES SKINNED OUT AND THEIR
 FLESH CUT INTO STRIPS FOR SALTING. WHEN THE WIND WAS IN THE EAST A SMELL CAME A
CROSS THE HARBOR FROM THE SHARK FACTORY; BUT TODAY THERE WAS ONLY THE FAINT EDGE
 OF THE ODOR BECAUSE THE WIND HAD BACKED  INTO THE NORTH AND THEN DROPPED OF AN
D IT WAS PLEASANT AND SUNNY ON THE TERRACE. SANTIAGO, THE BOY SAID. YES, THE OLD
 MAN SAID. HE WAS HOLDING HIS GLASS AND THINKING OF MANY YEARS AGO. CAN I GO OUT
 TO GET SARDINES FOR YOU FOR TOMORROW? NO. GO AND PLAY BASEBALL. I CAN STILL ROW
 AND ROGELIO WILL THROW THE NET. I WOULD LIKE TO GO. IF I CANNOT FISH WITH YOU,
I WOULD LIKE TO SERVE IN SOME WAY. YOU BOUGHT ME A BEER, THE OLD MAN SAID. YOU A
RE ALREADY A MAN. HOW OLD WAS I WHEN YOU FIRST TOOK ME IN A BOAT? FIVE AND YOU N
EARLY WERE KILLED WHEN I BROUGHT THE FISH IN TOO GREEN AND HE NEARLY TORE THE BO
AT TO PIECES. CAN YOU REMEMBER? I CAN REMEMBER THE TAIL SLAPPING AND BANGING AND
 THE THWART BREAKING AND THE NOISE OF THE CLUBBING. I CAN REMEMBER YOU THROWING
ME INTO THE BOW WHERE THE WET COILED LINES WERE AND FEELING THE WHOLE BOAT SHIVE
R AND THE NOISE OF YOU CLUBBING HIM LIKE CHOPPING A TREE DOWN AND THE SWEET BLOO
D SMELL ALL OVER ME. CAN YOU REALLY REMEMBER THAT OR DID I JUST TELL IT TO YOU?
I REMEMBER EVERYTHING FROM WHEN WE FIRST WENT TOGETHER. THE OLD MAN LOOKED AT HI
M WITH HIS SUNBURNED, CONFIDENT LOVING EYES. IF YOU WERE MY BOY ID TAKE YOU OUT
AND GAMBLE, HE SAID. BUT YOU ARE YOUR FATHERS AND YOUR MOTHERS AND YOU ARE IN A
LUCKY BOAT. MAY I GET THE SARDINES? I KNOW WHERE I CAN GET FOUR BAITS TOO. I HAV
E MINE LEFT FROM TODAY. I PUT THEM IN SALT IN THE BOX. LET ME GET FOUR FRESH ONE
S. ONE, THE OLD MAN SAID. HIS HOPE AND HIS CONFIDENCE HAD NEVER GONE. BUT NOW TH
EY WERE FRESHENING AS WHEN THE BREEZE RISES. TWO, THE BOY SAID. TWO, THE OLD MAN
 AGREED. YOU DIDNT STEAL THEM? I WOULD, THE BOY SAID. BUT I BOUGHT THESE. THANK
YOU, THE OLD MAN SAID. HE WAS TOO SIMPLE TO WONDER WHEN HE HAD ATTAINED HUMILITY
. BUT HE KNEW HE HAD ATTAINED IT AND HE KNEW IT WAS NOT DISGRACEFUL AND IT CARRI
ED NO LOSS OF TRUE PRIDE. TOMORROW IS GOING TO BE A GOOD DAY WITH THIS CURRENT,
HE SAID. WHERE ARE YOU GOING? THE BOY ASKED. FAR OUT TO COME IN WHEN THE WIND SH
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IFTS. I WANT TO BE OUT BEFORE IT IS LIGHT. ILL TRY TO GET HIM TO WORK FAR OUT, T
HE BOY SAID. THEN IF YOU HOOK SOMETHING TRULY BIG WE CAN COME TO YOUR AID. HE DO
ES NOT LIKE TO WORK TOO FAR OUT. NO, THE BOY SAID. BUT I WILL SEE SOMETHING THAT
 HE CANNOT SEE SUCH AS A BIRD WORKING AND GET HIM TO COME OUT AFTER DOLPHIN. ARE
 HIS EYES THAT BAD? HE IS ALMOST BLIND. IT IS STRANGE, THE OLD MAN SAID. HE NEVE
R WENT TURTLE-ING. THAT IS WHAT KILLS THE EYES. BUT YOU WENT TURTLE-ING FOR YEAR
S OFF THE MOSQUITO COAST AND YOUR EYES ARE GOOD. I AM A STRANGE OLD MAN. BUT ARE
 YOU STRONG ENOUGH NOW FOR A TRULY BIG FISH? I THINK SO. AND THERE ARE MANY TRIC
KS. LET US TAKE THE STUFF HOME, THE BOY SAID. SO I CAN GET THE CAST NET AND GO A
FTER THE SARDINES. THEY PICKED UP THE GEAR FROM THE BOAT. THE OLD MAN CARRIED TH
E MAST ON HIS SHOULDER AND THE BOY CARRIED THE WOODEN BOX WITH THE COILED, HARD-
BRAIDED BROWN LINES, THE GAFF AND THE HARPOON WITH ITS SHAFT. THE BOX WITH THE B
AITS WAS UNDER THE STERN OF THE SKIFF ALONG WITH THE CLUB THAT WAS USED TO SUBDU
E THE BIG FISH WHEN THEY WERE BROUGHT ALONGSIDE. NO ONE WOULD STEAL FROM THE OLD
 MAN BUT IT WAS BETTER TO TAKE THE SAIL AND THE HEAVY LINES HOME AS THE DEW WAS
BAD FOR THEM AND, THOUGH HE WAS QUITE SURE NO LOCAL PEOPLE WOULD STEAL FROM HIM,
 THE OLD MAN THOUGHT THAT A GAFF AND A HARPOON WERE NEEDLESS TEMPTATIONS TO LEAV
E IN A BOAT. THEY WALKED UP THE ROAD TOGETHER TO THE OLD MANS SHACK AND WENT IN
THROUGH ITS OPEN DOOR. THE OLD MAN LEANED THE MAST WITH ITS WRAPPED SAIL AGAINST
 THE WALL AND THE BOY PUT THE BOX AND THE OTHER GEAR BESIDE IT. THE MAST WAS NEA
RLY AS LONG AS THE ONE ROOM OF THE SHACK. THE SHACK WAS MADE OF THE TOUGH BUD-SH
IELDS OF THE ROYAL PALM WHICH ARE CALLED GUANO AND IN IT THERE WAS A BED, A TABL
E, ONE CHAIR, AND A PLACE ON THE DIRT FLOOR TO COOK WITH CHARCOAL. ON THE BROWN
WALLS OF THE FLATTENED, OVERLAPPING LEAVES OF THE STURDY FIBERED GUANO THERE WAS
 A PICTURE IN COLOR OF THE SACRED HEART OF JESUS AND ANOTHER OF THE VIRGIN OF CO
BRE. THESE WERE RELICS OF HIS WIFE. ONCE THERE HAD BEEN A TINTED  PHOTOGRAPH OF
HIS WIFE ON THE WALL BUT HE HAD TAKEN IT DOWN BECAUSE IT MADE HIM TOO LONELY TO
SEE IT AND IT WAS ON THE SHELF IN THE CORNER UNDER HIS CLEAN SHIRT. WHAT DO YOU
HAVE TO EAT? THE BOY ASKED. A POT OF YELLOW RICE WITH FISH. DO YOU WANT SOME? NO
. I WILL EAT AT HOME. DO YOU WANT ME TO MAKE THE FIRE? NO. I WILL MAKE IT LATER
ON. OR I MAY EAT THE RICE COLD. MAY I TAKE THE CAST NET? OF COURSE. THERE WAS NO
 CAST NET AND THE BOY REMEMBERED WHEN THEY HAD SOLD IT. BUT THEY WENT THROUGH TH
IS FICTION EVERY DAY. THERE WAS NO POT OF YELLOW RICE AND FISH AND THE BOY KNEW
THIS TOO. EIGHTY-FIVE IS A LUCKY NUMBER, THE OLD MAN SAID. HOW WOULD YOU LIKE TO
  SEE ME BRING ONE IN THAT DRESSED OUT OVER A THOUSAND POUNDS? ILL GET THE CASE
NET AND GO FOR SARDINES. WILL YOU SIT IN THE SUN IN THE DOORWAY? YES. I HAVE YES
TERDAYS PAPER AND I WILL READ THE BASEBALL. THE BOY DID NOT KNOW WHETHER YESTERD
AYS PAPER WAS A FICTION TOO. BUT THE OLD MAN BROUGHT IT OUT FROM UNDER THE BED.
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ES NOT LIKE TO WORK TOO FAR OUT. NO, THE BOY SAID. BUT I WILL SEE SOMETHING THAT
 HE CANNOT SEE SUCH AS A BIRD WORKING AND GET HIM TO COME OUT AFTER DOLPHIN. ARE
 HIS EYES THAT BAD? HE IS ALMOST BLIND. IT IS STRANGE, THE OLD MAN SAID. HE NEVE
R WENT TURTLE-ING. THAT IS WHAT KILLS THE EYES. BUT YOU WENT TURTLE-ING FOR YEAR
S OFF THE MOSQUITO COAST AND YOUR EYES ARE GOOD. I AM A STRANGE OLD MAN. BUT ARE
 YOU STRONG ENOUGH NOW FOR A TRULY BIG FISH? I THINK SO. AND THERE ARE MANY TRIC
KS. LET US TAKE THE STUFF HOME, THE BOY SAID. SO I CAN GET THE CAST NET AND GO A
FTER THE SARDINES. THEY PICKED UP THE GEAR FROM THE BOAT. THE OLD MAN CARRIED TH
E MAST ON HIS SHOULDER AND THE BOY CARRIED THE WOODEN BOX WITH THE COILED, HARD-
BRAIDED BROWN LINES, THE GAFF AND THE HARPOON WITH ITS SHAFT. THE BOX WITH THE B
AITS WAS UNDER THE STERN OF THE SKIFF ALONG WITH THE CLUB THAT WAS USED TO SUBDU
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E THE BIG FISH WHEN THEY WERE BROUGHT ALONGSIDE. NO ONE WOULD STEAL FROM THE OLD
 MAN BUT IT WAS BETTER TO TAKE THE SAIL AND THE HEAVY LINES HOME AS THE DEW WAS
BAD FOR THEM AND, THOUGH HE WAS QUITE SURE NO LOCAL PEOPLE WOULD STEAL FROM HIM,
 THE OLD MAN THOUGHT THAT A GAFF AND A HARPOON WERE NEEDLESS TEMPTATIONS TO LEAV
E IN A BOAT. THEY WALKED UP THE ROAD TOGETHER TO THE OLD MANS SHACK AND WENT IN
THROUGH ITS OPEN DOOR. THE OLD MAN LEANED THE MAST WITH ITS WRAPPED SAIL AGAINST
 THE WALL AND THE BOY PUT THE BOX AND THE OTHER GEAR BESIDE IT. THE MAST WAS NEA
RLY AS LONG AS THE ONE ROOM OF THE SHACK. THE SHACK WAS MADE OF THE TOUGH BUD-SH
IELDS OF THE ROYAL PALM WHICH ARE CALLED GUANO AND IN IT THERE WAS A BED, A TABL
E, ONE CHAIR, AND A PLACE ON THE DIRT FLOOR TO COOK WITH CHARCOAL. ON THE BROWN
WALLS OF THE FLATTENED, OVERLAPPING LEAVES OF THE STURDY FIBERED GUANO THERE WAS
 A PICTURE IN COLOR OF THE SACRED HEART OF JESUS AND ANOTHER OF THE VIRGIN OF CO
BRE. THESE WERE RELICS OF HIS WIFE. ONCE THERE HAD BEEN A TINTED  PHOTOGRAPH OF
HIS WIFE ON THE WALL BUT HE HAD TAKEN IT DOWN BECAUSE IT MADE HIM TOO LONELY TO
SEE IT AND IT WAS ON THE SHELF IN THE CORNER UNDER HIS CLEAN SHIRT. WHAT DO YOU
HAVE TO EAT? THE BOY ASKED. A POT OF YELLOW RICE WITH FISH. DO YOU WANT SOME? NO
. I WILL EAT AT HOME. DO YOU WANT ME TO MAKE THE FIRE? NO. I WILL MAKE IT LATER
ON. OR I MAY EAT THE RICE COLD. MAY I TAKE THE CAST NET? OF COURSE. THERE WAS NO
 CAST NET AND THE BOY REMEMBERED WHEN THEY HAD SOLD IT. BUT THEY WENT THROUGH TH
IS FICTION EVERY DAY. THERE WAS NO POT OF YELLOW RICE AND FISH AND THE BOY KNEW
THIS TOO. EIGHTY-FIVE IS A LUCKY NUMBER, THE OLD MAN SAID. HOW WOULD YOU LIKE TO
  SEE ME BRING ONE IN THAT DRESSED OUT OVER A THOUSAND POUNDS? ILL GET THE CASE
NET AND GO FOR SARDINES. WILL YOU SIT IN THE SUN IN THE DOORWAY? YES. I HAVE YES
TERDAYS PAPER AND I WILL READ THE BASEBALL. THE BOY DID NOT KNOW WHETHER YESTERD
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THE CLAVICHORD AND HOW TO PLAY IT. #MARGERY HALFORD. CLAVIER 9(2), 38-41 (1970).
#

THE CLAVICHORD IS ONE OF THE MOST SENSITIVE AND EXPRESSIVE MUSICAL INSTRUMENTS, DESPITE THE FACT THAT ITS CONSTRUCTION IS EXTREMELY SIMPLE.

ESSENTIALLY, THE CLAVICHORD IS A SHALLOW RECTANGULAR BOX WHOSE FRAGILE STRINGS, UNDER LIGHT TENSION, ARE STRUNG HORIZONTALLY FROM A SINGLE BRIDGE OVER A THIN SOUNDBOARD. THE KEYS ARE SIMPLE LEVERS WITH A BRASS BLADE CALLED A TANGENT MOUNTED VERTICALLY ON THE FAR END. WHEN A KEY IS DEPRESSED, THIS TANGENT STRIKES THE STRING AT THE POINT WHERE IT FORMS A NODE, LEAVING THE REST OF THE STRING IN FREE VIBRATION. THE SOUND PRODUCED IS EXTRAORDINARILY RICH IN OVERTONES. THE TONE OF THE CLAVICHORD DOES NOT EXIST READY-MADE AS IT DOES ON THE PIANO AND HARPSICHORD; IT IS FORMED AND SHAPED BY THE FINGER, AS ON A BOWED STRINGED INSTRUMENT, WITH THE RESULT BEING A GENUINE, DIRECT, LIVING "FEEL OF THE STRING" (SAITENGEFUHL). AS LONG AS HIS FINGER REMAINS IN CONTACT WITH THE KEY, THE PLAYER RETAINS CONTROL OF THE SOUND. THE CLAVICHORD IS THE LEAST MECHANIZED AND THE MOST RESPONSIVE OF ALL KEYBOARD INSTRUMENTS IN THAT IT MEETS THE PLAYER HALFWAY IN ITS INSTANT AND FAITHFUL TRANSMISSION OF HIS SLIGHTEST MUSICAL INTENTIONS.

THE TONAL CAPACITY OF THE CLAVICHORD RANGES FROM A MODEST MEZZOFORTE DOWNWARD THROUGH EVERY POSSIBLE SHADE OF SOFTNESS, WITH A DELICATE PIANISSIMO THAT IS ALL BUT INAUDIBLE. WITHIN THIS NARROW RANGE, THE SUBTLETIES AND NUANCES THAT CAN BE PRODUCED ARE LIMITED SOLELY BY THE SKILL OF THE PERFORMER.

EMBELLISHMENTS CAN BE PLAYED CRISPLY AND BRILLIANTLY. SHAKES, SNAPS, APPOGGIATURAS, TRILLS, TURNS, MORDENTS, AND SLIDES -- ALL SO CHARACTERISTIC OF THE PERIOD WHEN THE CLAVICHORD ENJOYED ITS GREATEST POPULARITY -- ARE IDEALLY SUITED TO THE INSTRUMENT'S EXQUISITE CLARITY AND RICHNESS OF TONE.

IN EARLY PAINTINGS OF CLAVICHORDISTS AT THE INSTRUMENT IT IS NOTED THAT THE BACK OF THE HAND HAS A MARKED DEPRESSION AT THE KNUCKLES, THE WRIST IS VERY LOW, AND THE VERY CURVED FINGERS APPEAR TO BE BARELY TOUCHING THE KEYS. THIS DEPICTION WAS NOT FROM ANY TECHNICAL DIFFICULTY IN PAINTING THE HUMAN HAND.

EARLY WRITER HAVE LEFT US DETAILED INSTRUCTIONS ON CLAVICHORD TECHNIC, PREDICATED ON THE PECULIARITIES OF THE INSTRUMENT ITSELF. THE ACTION IS SHALLOW AND VIRTUALLY WEIGHTLESS. IT IS A PHENOMENON OF THE DOUBLE-ENDED LEVER (SUCH AS THE CLAVICHORD KEY) THAT THE TONE PRODUCED BY A STRIKING FORCE (THE TANGENT) WILL SOUND BETTER, SWEETER, AND RICHER AT MAXIMUM LEVER LENGTH. FOR THIS REASON, THE KEYS OF THE CLAVICHORD, NATURALS AND RAISED ALIKE, ARE PLAYED AS NEAR TO THE FRONT EDGES AS POSSIBLE. EXCEPT FOR THE PLAYING OF OCTAVES, THE THUMB IS NEVER USED ON A RAISED KEY; LIKEWISE, THE LITTLE FINGER IS USED ONLY WHERE NECESSARY FOR OCTAVES OR FOR PRODUCING A MUSICAL PHRASING. OTHERWISE, THE THUMB IS CONSIDERED A MOST USEFUL FINGER FOR PASSING UNDER THE SECOND, THIRD, OR FOURTH FINGERS TO SMOOTH PASSAGE WORK AND TO FACILITATE PHRASING IN WIDE SKIPS.

THE HAND IS HELD WITH THE CUSTOMARY PIANIST'S HUMP, BUT THE KNUCKLES ARE INVERTED INSTEAD INTO A DEPRESSION. THE WRIST IS KEPT AS LOW AS POSSIBLE FOR EASE IN PLAYING, AND THE FINGERS ARE CURVED AS MUCH AS POSSIBLE. THIS POSITION GIVES MAXIMUM POWER AND THE GREATEST CONTROL OF FORCE, AND IT IS THE BASIS FOR GOOD TONE PRODUCTION.

THE PLAYER FEELS A SPRINGY RESISTANCE WHEN THE KEY IS DEPRESSED, AND THE AMOUNT OF TONE PRODUCED IS DETERMINED BY THE STRENGTH OF THE ATTACK. THE FINGER IS PLACED ON THE KEY -- NEVER ALLOWED TO STRIKE OR TO DROP -- WITH SUFFICIENT FORCE TO PRODUCE A TONE OF DESIRED VOLUME. A NOTE PLAYED WITH INSUFFICIENT FORCE WILL SOUND HOARSE AND INDISTINCT, AND ONE PLAYED WITH EXCESSIVE FORCE WILL SOUND OVERSTRAINED. C.P.E. BACH ADVISED PLAYING THE KEYS "FIRMLY WITH A CERTAIN FORCE; NEITHER ATTACKING THE NOTES ROUGHLY, NOR, ON THE OTHER HAND, FEEBLY SNATCHING AT THEM."

THE FINGERS SHOULD LIE CLOSE TOGETHER, EXCEPT IN MAKING LEAPS, WHEN THE HAND SHOULD BE EXTENDED IN READINESS FOR PLAYING A NOTE AS QUICKLY AS POSSIBLE. ONE SHOULD USE AS LITTLE MOVEMENT AS POSSIBLE AVOID SQUANDERING OF ENERGY, ALL EXERTION AND UNNECESSARY FORCE, AND ALLOW ONLY THE TOP JOINTS OF THE FINGERS TO MOVE. THE PROPER MOVEMENT IS PLACING THE FINGER ON THE KEY TO PRODUCE SOUND IN ONE SMOOTH ACTION, THEN HOLDING THIS STRIKING FORCE IN EQUILIBRIUM FOR THE

DURATION OF THE TONE SO THAT THE SOUND DOES NOT WAVER, I.E., EITHER SHARP OR FLAT FROM FLUCTUATION OF PRESSURE. THIS TOUCH IS USED TO PRODUCE TONES FOR WHICH INFLECTIONS ARE NOT DESIRED. IN RELEASING THE KEY, A CARESSING STROKE, PERMITTING THE TIP OF THE FINGER TO GLIDE OFF THE KEY AND INTO THE PALM OF THE HAND, IS USED BOTH TO PROLING THE DURATION OF THE TONE AND TO TRANSFER THE WEIGHT OF THE PLAYING FINGER TO THE NEXT FINGER TO BE USED. FURTHERMORE, LEGATO IS ACHIEVED IN THIS WAY, TOGETHER WITH GREAT TONAL RICHNESS. THE GLIDING MOVEMENT PRESERVES ONE'S FEELING OF HOW MUCH WEIGHT TO USE FOR THE NEXT NOTE, THUS GREATLY FACILITATING THE TECHNICAL DEMANDS OF THE INSTRUMENT. BECAUSE OF THE SHORT LENGTH OF THE NATURAL KEYS ON THE CLAVICHORD, THIS GLIDING RELEASE IS EASY TO EFFECT AND IT FEELS QUITE NATURAL.

THE MOST CELEBRATED CHARACTERISTIC OF THE CLAVICHORD, AND THE ONE THAT HAS GIVEN RISE TO THE MOST EXTRAORDINARILY EFFUSIVE POETRY ABOUT THE INSTRUMENT, IS ITS ABILITY TO ALTER THE TONE AFTER A SOUND HAS BEEN PRODUCED. THIS ALTERATION OCCURS WHEN THE FINGER HOLDING THE KEY IS GENTLY SHAKEN. A SLIGHT ADDITION OF PRESSURE INCREASES THE VOLUME (AND, CONSEQUENTLY, RAISES THE PITCH SLIGHTLY), AND A REDUCTION OF PRESSURE DECREASES THE VOLUME (AND ALSO LOWERS THE PITCH SLIGHTLY). THE GENTLE FLUCTUATIONS PRODUCED BY ROCKING THE KEY UP AND DOWN, BUT NOT ENOUGH SO THE TANGENT LEAVES THE STRING, MINUTELY ALTER THE STRING LENGTH; THE RESULT IS A VIBRATO SIMILAR TO THAT POSSIBLE ON A BOWED STRINGED INSTRUMENT. THIS TREMBLING QUALITY (GERMAN "BEBUNG", FRENCH "BALANCEMENT", ITALIAN "TREMOLO") HAS GIVEN THE CLAVICHORD ITS REPUTATION AS A SOULFUL, TENDER INSTRUMENT.

THE SIGN TO INDICATE VIBRATO IS A SLUR WITH DOTS OVER A SINGLE NOTE. THE BEST EFFECT IS ACHIEVED WHEN THE FINGER WITHHOLDS ITS SHAKE UNTIL HALF THE VALUE OF THE NOTE HAS PASSED. THIS AND THE PORTATO ("TRAGEN DER TONE") ARE CLOSELY RELATED, THE DIFFERENCE BEING SOLELY IN THE NUMBER OF TIMES THE KEY IS PRESSED AFTER THE FINGER STROKE. SOMETIMES THE DIFFERENCE IS ROUGHLY INDICATED BY THE NUMBER OF DOTS OVER EACH NOTE, BUT BECAUSE THIS NOTATION WAS NOT A UNIFORM CONVENTION, IT CANNOT BE TAKEN AS A LITERAL INTERPRETATION OF THE "BEBUNG".

A CLEARLY PERCEPTIBLE ACCENT, < >, ON EACH NOTE RESULTS WHEN THE TONE HAS JUST ONE ADDITIONAL PRESSURE AND RELEASE, BUT A VIBRATO RESULTS WHEN THE KEY IS CLEARLY ROCKED. THIS TREATMENT IS BEST RESERVED FOR THE SLOWER, EXPRESSIVE PASSAGES, AND FOR THE MELODIC LINE, NOT THE ACCOMPANIMENT.

BURNEY, WRITING OF THE "BEBUNG" IN "THE PRESENT STATE OF MUSIC IN GERMANY", SAYS THIS OF C.P.E. BACH'S PLAYING IN HAMBURG IN 1772: "WHENEVER HE HAD A LONG NOTE TO EXPRESS, HE ABSOLUTELY CONTRIVED TO PRODUCE FROM HIS INSTRUMENT, A SILBERMANN CLAVICHORD, A CRY OF SORROW AND COMPLAINT, SUCH AS CAN ONLY BE EFFECTED UPON THE CLAVICHORD AND PERHAPS BY HIMSELF."

MUSIC WRITTEN ESPECIALLY FOR THE CLAVICHORD USUALLY HAD AN INTIMATE CHARACTER, AND IT WAS COMPOSED PRINCIPALLY BEFORE THE FIRST HALF OF THE 18TH CENTURY. DISPLAY PIECES OF A VIRTUOSO CHARACTER ARE GENERALLY UNSUITED TO THE PERSONAL QUALITIES OF THE CLAVICHORD. THERE IS A WEALTH OF LITERATURE, MAINLY OF LITTLE PIECES SUCH A RONDOS, STUDIES, FANTASIAS, SONATAS, AND LIEDER. CRAMER SAYS THAT THE ESPECIALLY REMARKABLE FEATURES OF CLAVICHORD MUSIC ARE "FLUIDITY, SUSTAINED MELODY DIFFUSED WITH EVER-VARYING LIGHT AND SHADOW, THE USE OF CERTAIN MUSICAL SHADING AND ALMOST COMPLETE ABSTINENCE FROM PASSAGES WITH ARPEGGIOS, LEAPS, AND BROKEN CHORDS; ALL THESE ARE IN KEEPING WITH THE CLAVICHORD."

THE BEST PERIOD OF THE CLAVICHORD WAS BETWEEN 1753 AND 1800, JUST BEFORE THE PIANOFORTE EFFECTIVELY BEGAN TO RIVAL IT.

C.F.DANIEL SCHUBART, THE FOREMOST POETICAL EULOGIST OF THE PERIOD, WROTE IN 1785 IN HIS "IDEE ZU EINER AESTHETIK DER TONKUNST": "THE CLAVICHORD, THAT INDIVIDUAL, MELANCHOLIC, INEXPRESSIVELY SWEET INSTRUMENT, HAS ADVANTAGES OVER THE HARPSICHORD AND THE FORTEPIANO WHEN MADE BY A MASTER OF HIS CRAFT. NOT ONLY MUSICAL COLORING, BUT ALSO THE MIDDLE TINTS, NOTES SWELLING AND DYING AWAY, MELTING TRILLS, HARDLY BREATHING UNDER THE FINGERS, PORTATO AND VIBRATO, IN A WORD, EXPRESSIONS FOR EVERY SHADE OF FEELING. ALL THIS CAN BE REPRODUCED AND CONJURED UP BY THE PRESSURE OF THE FINGER, THE VIBRATION AND THROB OF THE STRINGS, AND BY A TOUCH HEAVY OR GENTLE. THOSE WHO DO NOT LIKE BLUSTER, FRENZY AND STORM, WHOSE HEART FINDS FREQUENT AND WELCOME RELIEF IN THE OVERFLOW OF SWEET SENTIMENTS WILL PASS OVER THE HARPSICHORD AND CHOOSE A CLAVICHORD."

A LATER, LESS EFFUSIVE APPRECIATION OF ITS CHARACTER APPEARED IN WEIMAR IN 1836 BY THON IN HIS "ESSAYS ON STRINGED KEYBOARD INSTRUMENTS": "THE CLAVICHORD IS DISTINGUISHED BY A GENTLE, SINGING TONE, WHICH IS TRANSFORMED INTO A SORT OF "BEBUNG" BY MEANS OF SUSTAINED AND INTENSIFIED PRESSURE WHICH THE IMAGINATIVE ARTIST UNDERSTANDS HOW TO USE BRILLIANTLY, AND ESPECIALLY KNOWS HOW TO INTRODUCE INTO ADAGIO MOVEMENTS. FOR THIS REASON IT LENDS ITSELF PARTICULARLY WELL TO THE OUTPOURING OF BEAUTIFUL FEELINGS AND PLEASING MELODIES AND IS ESPECIALLY SUITED TO EXPRESS THE TEMPERAMENTAL DISPOSITTION OF THE SOUL WHICH IS SO GLADLY AND IN SUCH CHARMING WAYS REVEALS ITSELF IN ADAGIO MOVEMENTS."

CLAVICHORDS ARE READILY AVAILABLE TODAY FROM MASTER BUILDERS, MOSTLY EUROPEAN OR ENGLISH, WHOSE INSTRUMENTS HAVE GREAT STABILITY AND UNIFORMLY FINE CRAFTSMANSHIP. AN IDEAL INSTRUMENT FOR SMALL, PERSONAL, INTENSELY CREATIVE MUSIC MAKING, IT IS THE INSTRUMENT THAT EARLY PEDAGOGUES ALWAYS USED TO TRAIN THEIR STUDENTS IN THE FINE ASPECTS OF MUSICIANSHIP. ACCORDING TO MATTHESON, "THOSE WHO WANT TO JUDGE A SENSITIVE TOUCH AND A PURE STYLE SHOULD LEAD THEIR CANDIDATE TO A SIMPLE CLAVICHORD." IN THE OPINION OF WALTHER, "THIS INSTRUMENT IS, SO TO SPEAK, EVERY PLAYER'S ELEMENTARY GRAMMAR."

TODAY, MANY KEYBOARDISTS WHO MIGHT WISH TO PERFECT THEIR TOUCH AND TO REFINE THEIR SENSIBILITIES OUGHT TO FIND A RICH REWARD IN THE EXPRESSIVE POSSIBILITIES OF THE CLAVICHORD. THE SEEKERS WILL SURELY DISCOVER IN THE CLAVICHORD THE PERFECT COMPLEMENT TO THEIR MUSICIANSHIP.

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# APPENDIX C

# APPENDIX C. SAMPLE OUTPUT OF THE OLD MAN AND THE SEA AS PRODUCED BY MYRA, CAP/I, PAP AND CGP.

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1        THE OLD  MAN

 SYNTAX  DTR NON  VRB
 SYNTAXC DTR NON  VRB
          NONP   |VRBP       |
           AGENT |AGENTATIVE|

2        AND   THE   SEA  WE   .

 SYNTAX  CNJ   DTR   NON  VRB  EOS
 SYNTAXC CNJ   DTR   NON  VRB  EOS
         OTHER|  NONP  |VRBP      |
         OTHER|  AGENT |AGENTATIVE|

3        HEMINGWAY# HE    WAS     AN   OLD  MAN

 SYNTAX  NON        PRN   AUX     DTR  ADJ  NON
 SYNTAXC NON        PRN   AUX     DTR  ADJ  NON
           NONP     |NONP  |VRBP   |   NONP     |
           OBJECT   |OBJECT|STATIVE|   OBJECT   |

4        WHO  FISHED ALONE  IN  A    SKIFF IN   THE GULF STREAM AND   HE   HAD  GONE EIGHTY-FOUR DAYS NOW

 SYNTAX  RPN  NON    INT    PRP DTR  NON   PRP  DTR ADJ  NON    CNJ   PRN  AUX  VRB  ADJ         NON  INT
 SYNTAXC RPN  NON    INT    PRP DTR  NON   PRP  DTR ADJ  NON    CNJ   PRN  AUX  VRB  ADJ         NON  INT
         NONP | NONP |ADVP  |    PRPP    |       PRPP          |OTHER|NONP |VRBP      |   NONP        |ADVP |
         AGENT| AGENT|MANNER|  LOCATIVE  |     LOCATIVE        |OTHER|AGENT|AGENTATIVE|   TIME        |TIME |

         WITHOUT TAKING A    FISH .

 SYNTAX  PRP     VRB    DTR  NON  EOS
 SYNTAXC PRP     VRB    DTR  NON  EOS
         VRBP          |  NONP      |
         OTHER         |  OBJECT    |

5        IN  THE  FIRST FORTY DAYS A   BOY HAD  BEEN WITH HIM  .

 SYNTAX  PRP DTR  DTR   ADJ   NON  DTR NON AUX  AUX  PRP  PRN  EOS
 SYNTAXC PRP DTR  DTR   ADJ   NON  DTR NON AUX  AUX  PRP  PRN  EOS
                   PRPP           | NONP  | VRBP   |    PRPP     |
                   TIME           | OBJECT| STATIVE|    MANNER   |

6        BUT  AFTER FORTY DAYS WITHOUT A   FISH THE BOY'S PARENTS HAD  TOLD HIM

 SYNTAX  CNJ  PRP   ADJ   NON  PRP     DTR NON  DTR ADJ   NON     AUX  VRB  PRN
 SYNTAXC CNJ  PRP   ADJ   NON  PRP     DTR NON  DTR ADJ   NON     AUX  VRB  PRN
         OTHER|     PRPP     |    PRPP        |    NONP          |VRBP      |NONP  |
         OTHER|     TIME     |    MANNER      |    AGENT         |AGENTATIVE|OBJECT|

7        THAT THE OLD MAN WAS      NOW  DEFINITELY AND  FINALLY SALAD
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SYNTAX   ---- DTR  ADJ  NON  AUX     INT  ADJ        CNJ   INT     NON
SYNTAXC  ---- DTR  ADJ  NON  AUX     INT  ADJ        CNJ   INT     NON
         OTHER|   NONP       |VRBP  |     ADJP       |OTHER| ADVP |NONP  |
         OTHER|  OBJECT      |STATIVE|    TIME       |OTHER| TIME |OBJECT|

8        WHICH IS       THE WORST FORM OF   UNLUCKY

SYNTAX   RPN    AUX    DTR  ADJ   NON  PRP  NON
SYNTAXC  RPN    AUX    DTR  ADJ   NON  PRP  NON
         NONP  |VRBP   |          NONP             |
         OBJECT|STATIVE|          OBJECT           |

9        AND   THE  BOY  HAD  GONE AT   THEIR ORDERS IN   ANOTHER BOAT WHICH  CAUGHT THREE GOUD FISH

SYNTAX   CNJ   DTR  NON  AUX  VRB  PRP  DTR   NON     PRP DTR     NON  RPN    NON    DTR   ADJ  NON
SYNTAXC  CNJ   DTR  NON  AUX  VRB  PRP  DTR   NON     PRP DTR     NON  RPN    NON    DTR   ADJ  NON
         OTHER| NCNP    |VRBP      |    PRPP         |    PRPP        |NONP  |NONP  |     NONP      |
         OTHER|  AGENT  |AGENTATIVE|    LOCATIVE     |    LOCATIVE    |OBJECT|OBJECT|     OBJECT    |

10       IT    MADE       THE BOY SAD

SYNTAX   PRN   VRB        DTR ADJ NON
SYNTAXC  PRN   VRB        DTR ADJ NON
         NCNP |VRBP      |   NONP       |
         AGENT|AGENTATIVE|   OBJECT     |

11       TO    SEE

SYNTAX   PRP   VRB
SYNTAXC  PRP   VRB
         VRBP       |
         EXPERIENCER|

12       THE   OLD  MAN COME        IN   EACH DAY WITH HIS   SKIFF EMPTY

SYNTAX   DTR   ADJ  NON VRB         PRP  DTR  NON PRP  DTR  ADJ   NON
SYNTAXC  DTR   ADJ  NON VRB         PRP  DTR  NON PRP  DTR  ADJ   NON
               NONP     |VRBP      |     PRPP    |        PRPP        |
               AGENT    |AGENTATIVE|     TIME    |        MANNER      |

13       AND   HE    ALWAYS WENT DOWN  TO  HELP HIM    CARRY EITHER THE  PERMANENT DEFEAT .

SYNTAX   CNJ   PRN   INT    VRB PRP    PRP VRB  PRN    VRB   PRN    DTR  ADJ       NON   EOS
SYNTAXC  CNJ   PRN   INT    VRB PRP    PRP VRB  PRN    VRB   PRN    DTR  ADJ       NON   EOS
         OTHER|NONP | ADVP |VRBP      | VRBP  |NONP  |VRBP |NONP |          NONP            |
         OTHER|AGENT| TIME |AGENTATIVE| OTHER  |OBJECT|OTHER|OBJECT|         OBJECT          |

14       THE   OLD  MAN  WAS    THIN AND  GAUNT WITH DEEP WRINKLES   IN   THE  BACK     OF   HIS NECK .

SYNTAX   DTR   ADJ  NON  AUX    ADJ  CNJ   NON    PRP  ADJ  NON      PRP  DTR PRP       PRP  DTR  NON  EOS
SYNTAXC  DTR   ADJ  NON  AUX    ADJ  CNJ   NON    PRP  ADJ  NON      PRP  DTR PRP       PRP  DTR  NON  EOS
             NONP      |VRBP   |ADJP |OTHER|NONP  |      PRPP       | ADVP    |ADVP     |      PRPP        |
                     OBJECT    |STATIVE|OTHER|OTHER|OBJECT|     MANNER      | LOCATIVE|LOCATIVE|      OTHER        |

      15         THE  BROWN BLOTCHES OF   THE  BENEVOLENT SKIN CANCER THE  SUN  BRINGS FROM ITS  REFLECTION ON   THE  TROPIC SEA

        SYNTAX   DTR  ADJ   NON     PRP   DTR  ADJ        ADJ  NON    DTR  ADJ  NON    PRP  DTR  NON        PRP  DTR  ADJ    NON
        SYNTAXC  DTR  ADJ   NON     PRP   DTR  ADJ        ADJ  NON    DTR  ADJ  NON    PRP  DTR  NON        PRP  DTR  ADJ    NON
                                       NONP                          |     NONP       |      PRPP          |      PRPP           |
                                       OBJECT                        |     OBJECT     |      LOCATIVE      |      LOCATIVE       |

                 WERE    ON   HIS  CHEEKS .

        SYNTAX   AUX     PRP  DTR  NON    EOS
        SYNTAXC  AUX     PRP  DTR  NON    EOS
                 VRBP   |      PRPP           |
                 STATIVE|      LOCATIVE       |

      16         THE  BLOTCHES RAN       WELL   DOWN THE  SIDES OF  HIS   FACE

        SYNTAX   DTR  NON      VRB       NON    PRP  DTR  NON   PRP DTR   NON
        SYNTAXC  DTR  NON      VRB       NON    PRP  DTR  NON   PRP DTR   NON
                     NONP     |VRBP      |NONP  |   PRPP          |   PRPP      |
                     AGENT    |AGENTATIVE|OBJECT|   LOCATIVE      |   OTHER     |

      17         AND  HIS  HANDS  HAD         THE  DEEP-CREASED SCARS

        SYNTAX   CNJ  DTR  NON    AUX         DTR  ADJ          NON
        SYNTAXC  CNJ  DTR  NON    AUX         DTR  ADJ          NON
                 OTHER|NONP       |VRBP       |        NONP           |
                 OTHER|BENEFACTIVE|BENEFACTIVE|        OBJECT         |

      18         FROM HANDLING HEAVY FISH ON  THE  CORDS .

        SYNTAX   PRP  VRB      ADJ   NON  PRP DTR  NON   EOS
        SYNTAXC  PRP  VRB      ADJ   NON  PRP DTR  NON   EOS
                   VRBP       |  NONP    |     PRPP          |
                   AGENTATIVE |  OBJECT  |     LOCATIVE      |

      19         BUT  NONE  OF  THESE SCARS WERE    FRESH  .

        SYNTAX   CNJ  PRN   PRP DTR   NON   AUX     ADJ   EOS
        SYNTAXC  CNJ  PRN   PRP DTR   NON   AUX     ADJ   EOS
                 OTHER|       NONP         |VRBP   |   ADJP   |
                 OTHER|       OBJECT       |STATIVE|   OTHER  |

      20         THEY  WERE      AS   OLD

        SYNTAX   PRN   AUX      ----  VRB
        SYNTAXC  PRN   AUX      ----  VRB
                 NONP  |VRBP   |OTHER|VRBP |
                 OBJECT|STATIVE|OTHER|OTHER|

      21         AS   EROSIONS    IN  A     FISHLESS DESERT  .
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     SYNTAX   ----   VRB        PRP  DTR  ADJ      NON     EOS
     SYNTAXC  ----   VRB        PRP  DTR  ADJ      NON     EOS
              OTHER|VRBP      |            PRPP
              OTHER|AGENTATIVE|            LOCATIVE            |

   22         EVERYTHING ABOUT HIM   WAS     OLD    EXCEPT HIS  EYES

     SYNTAX   PRN         PRP   PRN   AUX     ADJ    PRP    DTR  NON
     SYNTAXC  PRN         PRP   PRN   AUX     ADJ    PRP    DTR  NON
                NONP    | PRPP      |VRBP   |ADJP |    PRPP         |
                OBJECT  | LOCATIVE |STATIVE|OTHER|     LOCATIVE     |

   23         AND    THEY   WERE    THE  SAME COLOR AS   THE  SEA

     SYNTAX   CNJ    PRN    AUX     DTR  DTR  NON   ----   DTR  NON
     SYNTAXC  CNJ    PRN    AUX     DTR  DTR  NON   ----   DTR  NON
              OTHER|NONP   |VRBP    |       NONP      |OTHER|  NONP   |
              OTHER|OBJECT|STATIVE|      OBJECT       |OTHER|  OBJECT |

   24         AND    WERE    CHEERFUL

     SYNTAX   CNJ    AUX     ADJ
     SYNTAXC  CNJ    AUX     ADJ
              OTHER|VRBP    |  ADJP  |
              OTHER|STATIVE|  OTHER |

   25         AND   UNDEFEATED .

     SYNTAX   CNJ   VRB         EOS
     SYNTAXC  CNJ   VRB         EOS
              OTHER|   VRBP         |
              OTHER|   AGENTATIVE   |
VERB NOT FOUND IN CLAUSE

   26         SANTIAGO

     SYNTAX   NON
     SYNTAXC  NON
                NONP  |
                OTHER |

   27         THE  BOY  SAID        TO   HIM   AS    THEY   CLIMBED THE  BANK FROM

     SYNTAX   DTR  NON  VRB         PRP  PRN   ----  PRN    VRB     DTR  NON  PRP
     SYNTAXC  DTR  NON  VRB         PRP  PRN   ----  PRN    VRB     DTR  NON  PRP
                NONP   |VRBP       |PRPP      |OTHER|NONP  | VRBP  |  NONP  |PRPP    |
                AGENT  |AGENTATIVE|EXPERIENCE|OTHER|OBJECT| OTHER |  OBJECT |LOCATIVE|

   28         WHERE THE  SKIFF WAS  HAULED UP    .

     SYNTAX   RPN   DTR  NON   AUX  VRB    NON  EOS
     SYNTAXC  RPN   DTR  NON   AUX  VRB    NON  EOS
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              NONP |   NONP   | VRBP        | NONP   |
              AGENT|   AGENT  | AGENTATIVE|  OBJECT |

     29       I     COULD GO   WITH YOU  AGAIN .

      SYNTAX  PRN   AUX   VRB  PRP  PRN  INT   EOS
      SYNTAXC PRN   AUX   VRB  PRP  PRN  INT   EOS
              NONP |VRBP       |  PRPP   |   ADVP   |
              AGENT|AGENTATIVE|  MANNER |   TIME   |

     30       WEVE  MADE        SOME MONEY .

      SYNTAX  NON   VRB         DTR  NON   EOS
      SYNTAXC NON   VRB         DTR  NON   EOS
              NONP |VRBP       |     NONP       |
              AGENT|AGENTATIVE|     OBJECT     |

     31       THE  OLD  MAN  HAD          TAUGHT THE  BOY

      SYNTAX  DTR  ADJ  NON  AUX          ADJ    DTR  NON
      SYNTAXC DTR  ADJ  NON  AUX          ADJ    DTR  NON
                NONP         |VRBP        | ADJP |  NONP   |
                BENEFACTIVE |BENEFACTIVE| OTHER|  OBJECT |

     32       TO   FISH

      SYNTAX  PRP  VRB
      SYNTAXC PRP  VRB
              VRBP       |
              AGENTATIVE|

     33       AND   THE  BOY  LOVED       HIM  .

      SYNTAX  CNJ   DTR  NON  VRB         PRN  EOS
      SYNTAXC CNJ   DTR  NON  VRB         PRN  EOS
              OTHER|  NONP   |VRBP       |  NONP   |
              OTHER|  AGENT  |AGENTATIVE|  OBJECT |
VERB NOT FOUND IN CLAUSE

     34       NO

      SYNTAX  ----
      SYNTAXC ----
              ADVP     |
              LOCATIVE|

     35       THE  OLD  MAN  SAID .

      SYNTAX  DTR  ADJ  NON  VRB  EOS
      SYNTAXC DTR  ADJ  NON  VRB  EOS
                   NONP      |VRBP       |
                   AGENT     |AGENTATIVE|
36         YOURE     WITH A   LUCKY BOAT .

  SYNTAX   VRB       PRP DTR   ADJ   NON  EOS
  SYNTAXC  VRB       PRP DTR   ADJ   NON  EOS
           VRBP      |         PRPP           |
           AGENTATIVE|         MANNER         |

37         STAY      WITH THEM .

  SYNTAX   VRB       PRP  PRN  EOS
  SYNTAXC  VRB       PRP  PRN  EOS
           VRBP      |   PRPP    |
           AGENTATIVE|   MANNER  |

38         BUT  REMEMBER

  SYNTAX   CNJ  VRB
  SYNTAXC  CNJ  VRB
           OTHER|VRBP      |
           OTHER|EXPERIENCER|

39         HOW   YOU   WENT      EIGHTY-SEVEN DAYS  WITHOUT FISH

  SYNTAX   RPN   PRN   VRB       NON          VRB   PRP     NON
  SYNTAXC  RPN   PRN   VRB       NON          VRB   PRP     NON
           NONP |NONP |VRBP      |  NONP     |VRBP |  PRPP     |
           AGENT|AGENT|AGENTATIVE|  OBJECT   |TIME |  MANNER   |

40         AND  THEN WE   CAUGHT     BIG    ONES   EVERY DAY  FOR  THREE WEEKS .

  SYNTAX   CNJ  ---- PRN  VRB        NON    PRN    DTR   NON  PRP  DTR   NON   EOS
  SYNTAXC  CNJ  ---- PRN  VRB        NON    PRN    DTR   NON  PRP  DTR   NON   EOS
             OTHER |NONP |VRBP      |NONP  |NONP  |  NONP  |       PRPP        |
             TIME  |AGENT|AGENTATIVE|OBJECT|OBJECT|  TIME  |       TIME        |

41         I         REMEMBER

  SYNTAX   PRN       VRB
  SYNTAXC  PRN       VRB
           NONP      |VRBP      |
           EXPERIENCE|EXPERIENCER|

42         THE  OLD MAN SAID .

  SYNTAX   DTR  ADJ NON VRB   EOS
  SYNTAXC  DTR  ADJ NON VRB   EOS
                NONP   |VRBP      |
                AGENT  |AGENTATIVE|

43         I         KNOW        YOU    DID  NOT  LEAVE ME

  SYNTAX   PRN       VRB         PRN    AUX  NEG  VRB   PRN
  SYNTAXC  PRN       VRB         PRN    AUX  NEG  VRB   PRN
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           NONP      |VRBP       |NONP  |     VRBP       |NONP  |
           EXPERIENCE|EXPERIENCER|OBJECT|     OTHER      |OBJECT|

44         BECAUSE YOU   DOUBTED .

  SYNTAX   ----    PRN   VRB       EOS
  SYNTAXC  ----    PRN   VRB       EOS
            OTHER |NONP | VRBP        |
            OTHER |AGENT| AGENTATIVE  |

45         IT     WAS     PAPA  MADE  ME     LEAVE .

  SYNTAX   PRN    AUX     ADJ   VRB   PRN    VRB   EOS
  SYNTAXC  PRN    AUX     ADJ   VRB   PRN    VRB   EOS
           NONP  |VRBP   |ADJP |VRBP |NONP  |  VRBP    |
           OBJECT|STATIVE|OTHER|OTHER|OBJECT|   UTHER  |

46         I      AM      A    BOY

  SYNTAX   PRN    AUX     DTR  NON
  SYNTAXC  PRN    AUX     DTR  NON
           NONP  |VRBP   |  NONP   |
           OBJECT|STATIVE|  OBJECT |

47         AND   I     MUST OBEY  HIM  .

  SYNTAX   CNJ   PRN   AUX  VRB   PRN  EOS
  SYNTAXC  CNJ   PRN   AUX  VRB   PRN  EOS
           OTHER|NONP |VRBP      |  NONP    |
           OTHER|AGENT|AGENTATIVE|  OBJECT  |

48         I          KNOW

  SYNTAX   PRN        VRB
  SYNTAXC  PRN        VRB
           NONP      |VRBP       |
           EXPERIENCE|EXPERIENCER|

49         THE  OLD  MAN  SAID .

  SYNTAX   DTR  ADJ  NON  VRB  EOS
  SYNTAXC  DTR  ADJ  NON  VRB  EOS
                NONP     |VRBP      |
                AGENT    |AGENTATIVE|

50         IT     IS      QUITE NORMAL .

  SYNTAX   PRN    AUX     INT   ADJ      EOS
  SYNTAXC  PRN    AUX     INT   ADJ      EOS
           NONP  |VRBP   |      ADJP        |
           OBJECT|STATIVE|      OTHER       |
 51          HE    HASNT       MUCH FAITH .

   SYNTAX   PRN   VRB          DTR  NON   EOS
   SYNTAXC  PRN   VRB          DTR  NON   EOS
            NONP |VRBP       |      NONP      |
            AGENT|AGENTATIVE|       OBJECT    |
VERB NOT FOUND IN CLAUSE

 52          NO

   SYNTAX   ----
   SYNTAXC  ----
            ADVP     |
            LOCATIVE|

 53          THE  OLD  MAN  SAID .

   SYNTAX   DTR  ADJ  NON  VRB  EOS
   SYNTAXC  DTR  ADJ  NON  VRB  EOS
                 NONP      |VRBP       |
                 AGENT     |AGENTATIVE|

 54          BUT   WE    HAVE .

   SYNTAX   CNJ   PRN   AUX  EOS
   SYNTAXC  CNJ   PRN   AUX  EOS
            OTHER|NONP |VRBP       |
            OTHER|AGENT|AGENTATIVE|

 55          HAVENT    WE   ?

   SYNTAX   VRB         PRN  EOS
   SYNTAXC  VRB         PRN  EOS
            VRBP       | NONP   |
            AGENTATIVE|  OBJECT |
VERB NOT FOUND IN CLAUSE

 56          YES

   SYNTAX   NON
   SYNTAXC  NON
            NONP |
            OTHER|

 57          THE  BOY  SAID .

   SYNTAX   DTR  NON  VRB  EOS
   SYNTAXC  DTR  NON  VRB  EOS
              NONP   |VRBP       |
              AGENT  |AGENTATIVE|

 58          CAN        I      OFFER YOU    A    BEER ON   THE  TERRACE
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     SYNTAX   AUX        PRN    VRB   PRN    DTR  NON  PRP  DTR  NON
     SYNTAXC  AUX        PRN    VRB   PRN    DTR  NON  PRP  DTR  NON
              VRBP      |NONP  |VRBP |NONP  | NONP    |     PRPP        |
              AGENTATIVE|OBJECT|OTHER|OBJECT| OBJECT  |     LOCATIVE    |

   59         AND  THEN WELL      TAKE  THE  STUFF HOME .

     SYNTAX   CNJ  ---- VRB        VRB   DTR  ADJ   NON  EOS
     SYNTAXC  CNJ  ---- VRB        VRB   DTR  ADJ   NON  EOS
                OTHER |VRBP      |VRBP |       NONP         |
                TIME  |AGENTATIVE|OTHER|       OBJECT       |
VERB NOT FOUND IN CLAUSE

   60         WHY  NOT  ?

     SYNTAX   RPN  NEG  EOS
     SYNTAXC  RPN  NEG  EOS
                   NONP     |
                   OTHER    |

   61         THE  OLD  MAN  SAID .

     SYNTAX   DTR  ADJ  NON  VRB  EOS
     SYNTAXC  DTR  ADJ  NON  VRB  EOS
                   NONP     |VRBP      |
                   AGENT    |AGENTATIVE|

   62         BETWEEN FISHERMEN .

     SYNTAX   PRP     VRB       EOS
     SYNTAXC  PRP     VRB       EOS
                    VRBP            |
                    AGENTATIVE      |

   63         THEY SAT         ON   THE  TERRACE

     SYNTAX   PRN  VRB         PRP  DTR  NON
     SYNTAXC  PRN  VRB         PRP  DTR  NON
              NONP |VRBP      |     PRPP        |
              AGENT|AGENTATIVE|     LOCATIVE    |

   64         AND   MANY OF   THE  FISHERMEN MADE       FUN  OF   THE  OLD  MAN

     SYNTAX   CNJ   PRN  PRP  DTR  NON       VRB        NON  PRP  DTR  ADJ  NON
     SYNTAXC  CNJ   PRN  PRP  DTR  NON       VRB        NON  PRP  DTR  ADJ  NON
              OTHER|          NONP          |VRBP      |        NONP           |
              OTHER|          AGENT         |AGENTATIVE|        OBJECT         |

   65         AND   HE    WAS   NOT  ANGRY .

     SYNTAX   CNJ   PRN   AUX   NEG  ADJ   EOS
     SYNTAXC  CNJ   PRN   AUX   NEG  ADJ   EOS
              OTHER|NONP  |VRBP      |  ADJP   |
              OTHER|AGENT|AGENTATIVE|   OTHER  |
VERB NOT FOUND IN CLAUSE

   66         OTHERS ,     OF  THE  OLDER FISHERMEN

     SYNTAX   PRN    ----  PRP  DTR  ADJ   NON
     SYNTAXC  PRN    ----  PRP  DTR  ADJ   NON
               NONP |OTHER|          PRPP          |
               OTHER|OTHER|          OTHER         |

   67         LOOKED     AT   HIM

     SYNTAX   VRB        PRP  PRN
     SYNTAXC  VRB        PRP  PRN
              VRBP      | PRPP    |
              AGENTATIVE| LOCATIVE|

   68         AND   WERE    SAD  .

     SYNTAX   CNJ   AUX     ADJ  EOS
     SYNTAXC  CNJ   AUX     ADJ  EOS
              OTHER|VPBP   |  ADJP   |
              OTHER|STATIVE|  OTHER  |

   69         BUT   THEY  DID  NOT    SHOW   IT

     SYNTAX   CNJ   PRN   AUX  NEG    NON    PRN
     SYNTAXC  CNJ   PRN   AUX  NEG    NON    PRN
              OTHER|NCNP |VRBP       |NONP  |NONP  |
              OTHER|AGENT|AGENTATIVE|OBJECT|OBJECT|

   70         AND   THEY  SPOKE      POLITELY ABOUT THE  CURRENT

     SYNTAX   CNJ   PRN   VRB        NON      PRP   DTR  NON
     SYNTAXC  CNJ   PRN   VRB        NON      PRP   DTR  NON
              OTHER|NONP |VRBP      | NONP   |     PRPP        |
              OTHER|AGENT|AGENTATIVE| OBJECT |     LOCATIVE    |

   71         AND   THE  DEPTHS THEY  HAD  DRIFTED THEIR LINES AT

     SYNTAX   CNJ   DTR  NON    PRN   AUX  VRB     DTR   NON   PRP
     SYNTAXC  CNJ   DTR  NON    PRN   AUX  VRB     DTR   NON   PRP
              OTHER|   NONP    |NONP | VRBP        |   NONP   |PRPP    |
              OTHER|   AGENT   |AGENT| AGENTATIVE  |   OBJECT |LOCATIVE|

   72         AND   THE  STEADY GOOD WEATHER

     SYNTAX   CNJ   DTR  ADJ    NON  VRB
     SYNTAXC  CNJ   DTR  ADJ    NON  VRB
              OTHER|     NONP      |VRBP       |
              OTHER|     AGENT     |AGENTATIVE|
73          AND   OF   WHAT THEY  HAD  SEEN .

  SYNTAX    CNJ   PRP  RPN  PRN   AUX  VRB  EOS
  SYNTAXC   CNJ   PRP  RPN  PRN   AUX  VRB  EOS
            OTHER|  PRPP    |NONP |  VRBP          |
            OTHER|  OTHER   |AGENT|  AGENTATIVE    |

74          THE  SUCCESSFUL FISHERMEN OF   THAT  DAY   WERE    ALREADY IN

  SYNTAX    DTR  ADJ        NON       PRP  ---   NON   AUX     INT     PRP
  SYNTAXC   DTR  ADJ        NON       PRP  ---   NON   AUX     INT     PRP
                       NONP                |OTHER|NONP |VRBP    | ADVP |PRPP     |
                       OBJECT              |OTHER|TIME |STATIVE| TIME  |LOCATIVE|

75          AND   HAD  BUTCHERED THEIR MARLIN OUT

  SYNTAX    CNJ   AUX  VRB       DTR   NON    PRP
  SYNTAXC   CNJ   AUX  VRB       DTR   NON    PRP
            OTHER|  VRBP        |  NONP     |PRPP     |
            OTHER|  AGENTATIVE  |  OBJECT   |LOCATIVE|

76          AND   CARRIED    THEM   LAID  FULL LENGTH ACROSS TWO  PLANKS ,     WITH TWO  MEN  STAGGERING AT   THE  END

  SYNTAX    CNJ   VRB        PRN    VRB   ADJ  NON    PRP    DTR  NON    ----  PRP  DTR  ADJ  NON        PRP  DTR  NON
  SYNTAXC   CNJ   VRB        PRN    VRB   ADJ  NON    PRP    DTR  NON    ----  PRP  DTR  ADJ  NON        PRP  DTR  NON
            OTHER|VRBP      |NONP  |VRBP |   NONP   |     PRPP        |OTHER|          PRPP            |  PRPP         |
            OTHER|AGENTATIVE|OBJECT|OTHER|   OBJECT |     LOCATIVE    |OTHER|          MANNER          |  LOCATIVE     |

            OF   EACH PLANK

  SYNTAX    PRP  DTR  NON
  SYNTAXC   PRP  DTR  NON
            PRPP           |
            OTHER          |

77          TO   THE  FISH HOUSE WHERE THEY  WAITED      FOR  THE  ICE  TRUCK

  SYNTAX    PRP  DTR  ADJ  NON   RPN   PRN   VRB         PRP  DTR  ADJ  NON
  SYNTAXC   PRP  DTR  ADJ  NON   RPN   PRN   VRB         PRP  DTR  ADJ  NON
                PRPP            |NONP |NONP |VRBP      |      PRPP          |
                LOCATIVE        |AGENT|AGENT|AGENTATIVE|      MANNER        |

78          TO   CARRY THEM

  SYNTAX    PRP  VRB   PRN
  SYNTAXC   PRP  VRB   PRN
            VRBP      |NONP  |
            AGENTATIVE|OBJECT|

79          THOSE      WHO        HAD        CAUGHT SHARKS HAD  TAKEN THEM  TO   THE  SHARK FACTORY ON   THE  OTHER SIDE

  SYNTAX    PRN        RPN        AUX        NON    VRB    AUX  VRB   PRN   PRP  DTR  NON   VRB     PRP  DTR  DTR   NON
  SYNTAXC   PRN        RPN        AUX        NON    VRB    AUX  VRB   PRN   PRP  DTR  NON   VRB     PRP  DTR  DTR   NON
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                 NONP       |NONP       |VRBP       |NONP  | VRBP |   VRBP  |NONP  |    PRPP        | VRBP |       PRPP          |
                 BENEFACTIVE|BENEFACTIVE|BENEFACTIVE|OBJECT| OTHER|   OTHER |OBJECT|    LOCATIVE    | OTHER|       LOCATIVE      |

                 OF   THE  COVE

         SYNTAX  PRP  DTR  NON
         SYNTAXC PRP  DTR  NON
                 PRPP          |
                 OTHER         |

 80              WHERE  THEY   WERE HOISTED ON    A    BLOCK

         SYNTAX  RPN    PRN    AUX  VRB     PRP  DTR  NON
         SYNTAXC RPN    PRN    AUX  VRB     PRP  DTR  NON
                 NONP  |NONP  | VRBP       |    PRPP       |
                 OBJECT|OBJECT| AGENTATIVE |    LOCATIVE   |

 81              AND    TACKLE       ,     THEIR LIVERS REMOVED ,     THEIR FINS CUT  OFF      AND   THEIR HIDES SKINNED OUT

         SYNTAX  CNJ    VRB          ----  DTR    ADJ    NON     ----  DTR   ADJ  NON  PRP     CNJ   DTR    ADJ   NON      PRP
         SYNTAXC CNJ    VRB          ----  DTR    ADJ    NON     ----  DTR   ADJ  NON  PRP     CNJ   DTR    ADJ   NON      PRP
                 OTHER|VRBP       |OTHER|        NONP           |OTHER|     NONP      |PRPP    |OTHER|        NONP          |PRPP    |
                 OTHER|AGENTATIVE |OTHER|        OBJECT         |OTHER|     OBJECT    |LOCATIVE|OTHER|        OBJECT        |LOCATIVE|

                 AND    THEIR FLESH CUT  INTO STRIPS

         SYNTAX  CNJ    DTR    ADJ   NON   PRP  NON
         SYNTAXC CNJ    DTR    ADJ   NON   PRP  NON
                 OTHER|      NONP         | PRPP      |
                 OTHER|      OBJECT       | LOCATIVE  |

 82              FOR   SALTING

         SYNTAX  PRP   VRB
         SYNTAXC PRP   VRB
                  VRBP        |
                  AGENTATIVE  |

 83              WHEN   THE   WIND WAS     IN   THE   EAST A    SMELL CAME  ACROSS THE  HARBOR FROM THE  SHARK FACTORY ;

         SYNTAX  RPN    DTR   NON  AUX     PRP  DTR   NON  DTR  NON   VRB   PRP     DTR  NON   PRP  DTR  ADJ   NON      EOS
         SYNTAXC RPN    DTR   NON  AUX     PRP  DTR   NON  DTR  NON   VRB   PRP     DTR  NON   PRP  DTR  ADJ   NON      EOS
                 NONP |  NONP    |VRBP    |   PRPP        |  NONP    |VRBP |     PRPP        |       PRPP              |
                 TIME |  OBJECT  |STATIVE |   LOCATIVE    |  OBJECT  |OTHER|     LOCATIVE    |       LOCATIVE          |

 84              BUT    TODAY THERE WAS     ONLY   THE  FAINT EDGE  OF    THE  ODOR

         SYNTAX  CNJ    INT   ----  AUX     INT    DTR  NON   VRB   PRP   DTR  NON
         SYNTAXC CNJ    INT   ----  AUX     INT    DTR  NON   VRB   PRP   DTR  NON
                 OTHER|ADVP  |OTHER|VRBP   |ADVP  |  NONP    |VRBP |     PRPP      |
                 OTHER|TIME  |OTHER|STATIVE|MANNER|  OBJECT  |OTHER|     OTHER     |
 85         BECAUSE THE  WIND HAD  BACKED INTO THE  NORTH

   SYNTAX   ----     DTR  NON  AUX  VRB    PRP  DTR  NON
   SYNTAXC  ----     DTR  NON  AUX  VRB    PRP  DTR  NON
              OTHER |  NONP    | VRBP       |    PRPP       |
              OTHER |  AGENT   | AGENTATIVE|    LOCATIVE    |

 86         AND  THEN DROPPED    OF

   SYNTAX   CNJ  ---- VRB        PRP
   SYNTAXC  CNJ  ---- VRB        PRP
              OTHER  |VRBP       |PRPP |
              TIME   |AGENTATIVE|OTHER|

 87         AND   IT    WAS     PLEASANT

   SYNTAX   CNJ   PRN    AUX     ADJ
   SYNTAXC  CNJ   PRN    AUX     ADJ
            OTHER|NONP  |VRBP   |  ADJP  |
            OTHER|OBJECT|STATIVE|  OTHER |

 88         AND   SUNNY      ON   THE  TERRACE .

   SYNTAX   CNJ   VRB        PRP  DTR  NON      EOS
   SYNTAXC  CNJ   VRB        PRP  DTR  NON      EOS
            OTHER|VRBP       |      PRPP           |
            OTHER|AGENTATIVE|       LOCATIVE       |
VERB NOT FOUND IN CLAUSE

 89         SANTIAGO

   SYNTAX   NON
   SYNTAXC  NON
              NONP  |
              OTHER |

 90         THE  BOY  SAID .

   SYNTAX   DTR  NON  VRB  EOS
   SYNTAXC  DTR  NON  VRB  EOS
              NONP   |VRBP       |
              AGENT  |AGENTATIVE|
VERB NOT FOUND IN CLAUSE

 91         YES

   SYNTAX   NON
   SYNTAXC  NON
            NONP |
            OTHER|

 92         THE  OLD  MAN  SAID .
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    SYNTAX   DTR  ADJ  NON  VRB  EOS
    SYNTAXC  DTR  ADJ  NON  VRB  EOS
                  NOMP      |VRBP       |
                  AGENT     |AGENTATIVE|

  93        HE    WAS  HOLDING HIS  GLASS

    SYNTAX   PRN   AUX  VRB     DTR  NON
    SYNTAXC  PRN   AUX  VRB     DTR  NON
             NOMP | VRBP       |  NOMP     |
             AGENT| AGENTATIVE |  OBJECT   |

  94        AND   THINKING   OF   MANY YEARS AGO  .

    SYNTAX   CNJ   VRB        PRP  DTR  ADJ   NON  EOS
    SYNTAXC  CNJ   VRB        PRP  DTR  ADJ   NON  EOS
             OTHER|VRBP      |         PRPP           |
             OTHER|AGENTATIVE|         TIME           |

  95        CAN        I      GO    OUT

    SYNTAX   AUX        PRN    VRB   PRP
    SYNTAXC  AUX        PRN    VRB   PRP
             VRBP      |NOMP  |VRBP |PRPP     |
             AGENTATIVE|OBJECT|OTHER|LOCATIVE|

  96        TO   GET   SARDINES FOR  YOU    FOR  TOMORROW ?

    SYNTAX   PRP  AUX   ADJ      PRP  PRN    PRP  NON       EOS
    SYNTAXC  PRP  AUX   ADJ      PRP  PRN    PRP  NON       EOS
             VRBP      |  ADJP  |PRPP        |        PRPP        |
             AGENTATIVE|  OTHER |BENEFACTIVE|        TIME        |
 VERB NOT FOUND IN CLAUSE

  97        NO

    SYNTAX   ----
    SYNTAXC  ----
             ADVP    |
             LOCATIVE|

  98        GO

    SYNTAX   VRB
    SYNTAXC  VRB
             VRBP      |
             AGENTATIVE|

  99        AND   PLAY  BASEBALL .

    SYNTAX   CNJ   NON   VRB      EOS
    SYNTAXC  CNJ   NON   VRB      EOS
             OTHER|NOMP |  VRBP       |
                OTHER|AGENT|  AGENTATIVE |

    100         I     CAN         STILL ROW

        SYNTAX  PRN   AUX         INT   VRB
        SYNTAXC PRN   AUX         INT   VRB
                NONP |VRBP       |ADVP |VRBP |
                AGENT|AGENTATIVE|TIME |OTHER|

    101         AND   ROGELIO WILL THROW THE  NET  .

        SYNTAX  CNJ   NON     AUX  VRB   DTR  NON  EOS
        SYNTAXC CNJ   NON     AUX  VRB   DTR  NON  EOS
                OTHER| NONP  |VRBP      |    NONP      |
                OTHER| AGENT |AGENTATIVE|    OBJECT    |

    102         I     WOULD       LIKE

        SYNTAX  PRN   AUX         NON
        SYNTAXC PRN   AUX         NON
                NONP |VRBP       |NONP  |
                AGENT,AGENTATIVE|OBJECT|

    103         TO   GO   .

        SYNTAX  PRP  VRB  EOS
        SYNTAXC PRP  VRB  EOS
                  VRBP        |
                  AGENTATIVE  |

    104         IF    I      CANNOT FISH WITH YOU

        SYNTAX  ----  PRN   AUX    VRB  PRP  PRN
        SYNTAXC ----  PRN   AUX    VRB  PRP  PRN
                OTHER|NONP | VRBP       |  PRPP    |
                OTHER|AGENT| AGENTATIVE|  MANNER  |

    105         I     WOULD       LIKE

        SYNTAX  PRN   AUX         NON
        SYNTAXC PRN   AUX         NON
                NONP |VRBP       |NONP  |
                AGENT|AGENTATIVE|OBJECT|

    106         TO   SERVE IN   SOME WAY  .

        SYNTAX  PRP  VRB   PRP  DTR  NON  EOS
        SYNTAXC PRP  VRB   PRP  DTR  NON  EOS
                VRBP      |     PRPP          |
                AGENTATIVE|     LOCATIVE      |

    107         YOU   BOUGHT      ME     A    BEER
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   SYNTAX   PRN   VRB          PRN     DTR  NON
   SYNTAXC  PRN   VRB          PRN     DTR  NON
            NONP  |VRBP        |NONP  |  NONP   |
            AGENT|AGENTATIVE|OBJECT|  OBJECT  |

108         THE  OLD  MAN  SAID .

   SYNTAX   DTR  ADJ  NON  VRB  EOS
   SYNTAXC  DTR  ADJ  NON  VRB  EOS
                 NONP      |VRBP         |
                 AGENT     |AGENTATIVE|

109         YOU     ARE      ALREADY A    MAN   .

   SYNTAX   PRN     AUX      INT     DTR  NON  EOS
   SYNTAXC  PRN     AUX      INT     DTR  NON  EOS
            NONP   |VRBP    | ADVP  |     NONP       |
            OBJECT|STATIVE| TIME   |     OBJECT     |

110         HOW     OLD     WAS     I

   SYNTAX   RPN     NON     AUX     PRN
   SYNTAXC  RPN     NON     AUX     PRN
            NONP   |NONP   |VRBP   |NONP  |
            OBJECT|OBJECT|STATIVE|OBJECT|

111         WHEN  YOU   FIRST TOOK       ME     IN   A   BOAT ?

   SYNTAX   RPN   PRN   PRN   VRB        PRN    PRP  DTR  NON  EOS
   SYNTAXC  RPN   PRN   PRN   VRB        PRN    PRP  DTR  NON  EOS
            NONP |NONP |NONP |VRBP      |NONP  |     PRPP           |
            TIME |AGENT|TIME |AGENTATIVE|OBJECT|     LOCATIVE       |

112         FIVE AND  YOU  NEARLY WERE KILLED

   SYNTAX   PRN  CNJ  PRN  INT     AUX  VRB
   SYNTAXC  PRNC           INT     AUX  VRB
                 NONP      |ADVP   | VRBP        |
                 AGENT     |MANNER| AGENTATIVE|

113         WHEN  I     BROUGHT      THE  FISH IN        TOO     GREEN

   SYNTAX   RPN   PRN   VRB          DTR  NON  PRP       INT     NON
   SYNTAXC  RPN   PRN   VRB          DTR  NON  PRP       INT     NON
            NONP |NONP |VRBP        |  NONP   |ADVP     |ADVP   |NONP  |
            TIME |AGENT|AGENTATIVE|  OBJECT |LOCATIVE|MANNER|OBJECT|

114         AND   HE    NEARLY TORE  THE  BOAT TO   PIECES .

   SYNTAX   CNJ   PRN   INT    NON   DTR  NON  PRP  VRB    EOS
   SYNTAXC  CNJ   PRN   INT    NON   DTR  NON  PRP  VRB    EOS
            OTHER|NONP |ADVP  |NONP |  NONP   |   VRBP       |
          OTHER|AGENT|MANNER|AGENT|  AGENT  |   AGENTATIVE   |

  115          CAN          YOU    REMEMBER ?

     SYNTAX   AUX          PRN    VRB      EOS
     SYNTAXC  AUX          PRN    VRB      EOS
              VRBP       |NONP  |     VRBP      |
              AGENTATIVE|OBJECT|      OTHER     |

  116          I           CAN  REMEMBER THE  TAIL SLAPPING AND  BANGING

     SYNTAX   PRN          AUX  VRB      DTR  NON  VRB      CNJ  VRB
     SYNTAXC  PRN          AUX  VRB      DTR  NON  VRBC
              NONP       | VRBP        | NONP  |         VRBP        |
              EXPERIENCE| EXPERIENCER | OBJECT |         OTHER       |

  117          AND   THE   THWART BREAKING    AND   THE   NOISE

     SYNTAX   CNJ   DTR  NON     VRB         CNJ   DTR  NON
     SYNTAXC  CNJ   DTR  NON     VRB         CNJ   DTR  NON
              OTHER|   NONP     |VRBP       |OTHER|  NONP    |
              OTHER|   AGENT    |AGENTATIVE|OTHER|  OBJECT  |

 IHE806I DATA INTERRUPT AT OFFSET +05184 FROM ENTRY POINT CASEASSIGNMENT


 THE FOLLOWING CLAUSE RAISED THE ERROR CONDITION CLAUSEIN.PRINTIN=*OF THE CLUBBING .            ';



  119          I           CAN  REMEMBER YOU     THROWING ME     INTO THE  BOW

     SYNTAX   PRN          AUX  VRB      PRN     VRB      PRN    PRP  DTR  NON
     SYNTAXC  PRN          AUX  VRB      PRN     VRB      PRN    PRP  DTR  NON
              NONP       | VRBP        |NONP  |  VRBP   |NONP  |   PRPP        |
              EXPERIENCE| EXPERIENCER |OBJECT|  OTHER  |OBJECT|   LOCATIVE    |

  120          WHERE THE  WET  COILED      LINES WERE

     SYNTAX   RPN   DTR  NON  VRB          VRB   AUX
     SYNTAXC  RPN   DTR  NON  VRB          VRB   AUX
              NONP |  NONP   |VRBP        |VRBP |VRBP |
              AGENT|  AGENT  |AGENTATIVE|OTHER|OTHER|

  121          AND   FEELING THE  WHOLE BOAT SHIVER      AND   THE  NOISE

     SYNTAX   CNJ   NON      DTR  DTR   NON  VRB         CNJ   DTR  NON
     SYNTAXC  CNJ   NON      DTR  DTR   NON  VRB         CNJ   DTR  NON
              OTHER| NONP  |      NONP        |VRBP       |OTHER|  NONP    |
```

# APPENDIX D

# APPENDIX D. DETAILED ERROR ANALYSIS OF DOCUMENTS ANALYZED BY MYRA.

Two types of error are defined for this analysis: type A and type B. Type A errors are those errors generated by problems in the computer program, and do not reflect weaknesses in the rules. Type B errors are inaccuracies caused by a grammatical assignment rule described in Chapter III.

"The Need for a More Precise Definition of 'Algorithm' -- Basic Dictionary

| Sentence Number | Number of Words | Total Number of Errors | Type-A Errors | Type-B Errors | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | NON | VRB | ADJ | ADV | PTC | DTR | PRN | PRP | INT | SUB | INF |
| 1 | 9 | 1 | | 1 | | | | | | | | | | |
| 2 | 0 | | | | | | | | | | | | | |
| 3 | 0 | | | | | | | | | | | | | |
| 4 | 13 | 4 | | 2 | 2 | | | | | | | | | |
| 5 | 16 | 2 | 1 | | 1 | | 1 | | | | | | | |
| 6 | 30 | 3 | 1 | | | 3 | | | | | | | | |
| 7 | 6 | | | | | | | | | | | | | |
| 8 | 32 | 4 | | 1 | | | 1 | | | | | | | |
| 9 | 29 | 2 | 1 | | | 1 | | | | | | | 1 | |
| 10 | 13 | 1 | | | | 1 | | | | | | | | |
| 11 | 8 | | | | | | | | | | | | | |
| 12 | 28 | 1 | | 1 | | | | | | | | | | |
| 13 | 21 | 1 | | | | 2 | 1 | | | | | | | |
| 14 | 32 | 2 | | | | 1 | 1 | | | | | | | |
| 15 | 20 | | | | | | | | | | | | | |
| 16 | 31 | 4 | | 2 | 1 | 1 | | | | | | | | |
| 17 | 43 | 2 | | | | | | | | | | | | |
| 18 | 19 | 2 | | 1 | 1 | | 1 | | | | | | | |
| 19 | 51 | 9 | | 2 | 3 | 1 | 3 | | | | | | | |
| 20 | 28 | 5 | | 1 | 2 | | 2 | | | | | | | |
| 21 | 26 | 6 | 3 | 2 | 2 | 1 | | | | | | | 1 | |
| 22 | 16 | 4 | 1 | 2 | | 1 | | | | | | | | |
| 23 | 22 | 2 | | 1 | | | 1 | | | | | | | |
| 24 | 7 | | | | | | | | | | | | | |
| 25 | 7 | | | | | | | | | | | | | |

"The Need for a More Precise Definition of 'Algorithm'" -- Basic Dictionary

| Sentence Number | Number of Words | Total Number of Errors | Type-A Errors | Type-B Errors | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | NON | VRB | ADJ | ADV | PTC | DTR | PRN | PRP | INT | SUB | INF |
| 26 | 15 | | | | | | | | | | | | | |
| 27 | 23 | | | | | | | | | | | | | |
| 28 | 5 | 1 | | | | | 1 | | | | | | | |
| 29 | 19 | 4 | | 1 | 1 | 1 | | 1 | | | | | | |
| 30 | 8 | 1 | | | | | 1 | | | | | | | |
| 31 | 22 | 1 | | | 1 | | | | | | | | | |
| 32 | 10 | | | | | | | | | | | | | |
| 33 | 18 | 5 | | 2 | 1 | 2 | | | | | | | | |
| 34 | 6 | 7 | 1 | 2 | 4 | 1 | | | | | | | | |
| 35 | 21 | 1 | 1 | | 1 | | | | | | | | | |
| 36 | 22 | 1 | | | 1 | | | | | | | | | |
| 37 | 21 | 2 | | | 1 | | 1 | | | | | | | |
| 38 | 8 | | | | | | | | | | | | | |
| 39 | 19 | 4 | 2 | 2 | | 1 | | | 1 | | | | | |
| 40 | 21 | 2 | 1 | | 1 | | | | | 1 | | | | |
| 41 | 15 | | | | | | | | | | | | | |
| 42 | 6 | | | | | | | | | | | | | |
| 43 | 18 | 2 | | 1 | 1 | | | | | | | | | |
| 44 | 35 | 4 | 1 | 2 | | | 1 | | 1 | | | | | |
| 45 | 22 | 3 | 1 | 1 | 1 | | 1 | | | | | | | |
| 46 | 21 | 2 | | | 1 | | 1 | | | | | | | |
| 47 | 30 | 3 | | 1 | 2 | | | | | | | | | |
| 48 | 19 | 4 | | 2 | | | 2 | | | | | | | |
| 49 | 24 | | | | | | | | | | | | | |
| 50 | 54 | 9 | 2 | 5 | 2 | | 1 | 1 | | | | | | |

"The Need for a More Precise Definition of 'Algorithm'" -- Basic Dictionary

| Sentence Number | Number of Words | Total Number of Errors | Type-A Errors | Type-B Errors | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | NON | VRB | ADJ | ADV | PTC | DTR | PRN | PRP | INT | SUB | INF |
| 51 | 43 | 3 | 1 | 2 | 1 | | | | | | | | | |
| 52 | 32 | 3 | 1 | | 1 | | | 1 | | | | | | |
| 53 | 18 | | | | | | | | | | | | | |
| 54 | 8 | | | | | | | | | | | | | |
| 55 | 39 | 9 | 2 | 5 | 1 | | | 3 | | | | | | |
| 56 | 9 | | | | | | | | | | | | | |
| 57 | 25 | 3 | | 2 | 1 | | | | | | | | | |
| 58 | 45 | 1 | | | | | 1 | | | | | | | |
| 59 | 44 | 7 | | 2 | 3 | | 1 | 1 | | | | | | |
| 60 | 16 | | | | | | | | | | | | | |
| 61 | 23 | 1 | 1 | | | | 1 | | | | | | | |
| 62 | 29 | 2 | | | 1 | 1 | | | | | | | | |
| 63 | 27 | 4 | 1 | 1 | | 1 | | 1 | | | | | | |
| 64 | 21 | 1 | 1 | | | | | 1 | | | | | | |
| 65 | 7 | 3 | 1 | | 2 | | 1 | | | | | | | |
| 66 | 17 | 1 | | | | | 1 | | | | | | | |
| 67 | 40 | 1 | | | | 1 | | | | | | | | |
| 68 | 24 | 1 | | | | | 1 | | | | | | | |
| 69 | 24 | | | | | | | | | | | | | |
| 70 | 11 | | | | | | | | | | | | | |
| 71 | 31 | 5 | 1 | 1 | 1 | 2 | 1 | | | | | | 1 | |
| 72 | 45 | 3 | | 1 | 2 | | | | | | | | | |
| 73 | 36 | 3 | | 1 | 1 | | | 1 | | | | | | |
| 74 | 16 | 4 | | 2 | 1 | | | 1 | | | | | | |
| 75 | 15 | 1 | | | 1 | | | | | | | | | |

"The Need for a More Precise Definition of 'Algorithm'" -- Basic Dictionary

| Sentence Number | Number of Words | Total Number of Errors | Type-A Errors | Type-B Errors | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | NON | VRB | ADJ | ADV | PTC | DTR | PRN | PRP | INT | SUB | INF |
| 76 | 37 | 3 | | | 3 | | | | | | | | | |
| 77 | 16 | 1 | | | 1 | | | | | | | | | |
| 78 | 34 | 6 | 1 | 3 | 1 | 1 | 1 | | | | | | | |
| 79 | 39 | 2 | | | 1 | 1 | | | | | | | | |
| 80 | 32 | | | | | | | | | | | | | |
| 81 | 10 | 1 | | | 1 | | | | | | | | | |
| 82 | 48 | 4 | | 2 | 1 | 1 | | | | | | | | |
| 83 | 30 | | | | | | | | | | | | | |
| 84 | 43 | 1 | | | | | 1 | | | | | | | |
| 85 | 51 | | | | | | | | | | | | | |
| 86 | 25 | 6 | | | 3 | | 1 | 2 | | | | | | |
| 87 | 16 | 1 | | | | | 1 | | | | | | | |
| 88 | 16 | 1 | 1 | | | | | | | | | | 1 | |
| 89 | 7 | | | | | | | | | | | | | |
| 90 | 16 | 1 | | | | | 1 | | | | | | | |
| 91 | 8 | | | | | | | | | | | | | |
| 92 | 30 | 4 | | 1 | 3 | | | | | | | | | |
| 93 | 42 | 5 | 2 | 1 | 4 | | | | | | | | | |
| 94 | 22 | 2 | 1 | | 1 | 1 | | | | | | | | |
| 95 | 22 | 2 | | | 1 | | 1 | | | | | | | |
| 96 | 27 | 3 | | 1 | 1 | | 1 | | | | | | | |
| 97 | 16 | 1 | | 1 | | | | | | | | | | |
| TOTAL | 2231 | 21 | 28 | 60 | 73 | 22 | 34 | 12 | 2 | 1 | 1 | | 3 | |
| % | | 11% | 8% | 28% | 35% | 10% | 16% | 1% | 1% | .5% | .5% | | 1% | |

"The Need for a More Precise Definition of 'Algorithm'" -- Extended Dictionary

| Sentence Number | Number of Words | Total Number of Errors | Type-A Errors | Type-B Errors | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | NON | VRB | ADJ | ADV | PTC | DTR | PRN | PRP | INT | SUB | INF |
| 1 | 9 | 7 | | 1 | | | | | | | | | | |
| 2 | 0 | | | | | | | | | | | | | |
| 3 | 0 | | | | | | | | | | | | | |
| 4 | 23 | 4 | | 2 | 1 | | | | | | | | | |
| 5 | 16 | | | | | | | | | | | | | |
| 6 | 30 | 4 | 1 | | | | 3 | | | | | 1 | | |
| 7 | 6 | | | | | | | | | | | | | |
| 8 | 32 | | | | | | | | | | | | | |
| 9 | 29 | 1 | 1 | | | | | | | | | | | |
| 10 | 13 | 1 | 1 | | | | | | | | | | 1 | |
| 11 | 8 | | | | | | | | | | | | | |
| 12 | 28 | 1 | 1 | 1 | | | | | | | | | | |
| 13 | 21 | 1 | | | | | 1 | | | | | | | |
| 14 | 32 | 2 | | | | 1 | 1 | | | | | | | |
| 15 | 20 | | | | | | | | | | | | | |
| 16 | 31 | 4 | | 2 | 1 | 1 | | | | | | | | |
| 17 | 43 | | | | | | | | | | | | | |
| 18 | 19 | 2 | | 1 | 1 | | | | | | | | | |
| 19 | 51 | 8 | | 3 | 2 | 1 | 2 | | | | | | | |
| 20 | 28 | 1 | | | | | 1 | | | | | | | |
| 21 | 26 | | | | | | | | | | | | | |
| 22 | 16 | 2 | | | 1 | | 1 | | | | | | | |
| 23 | 22 | 1 | | | | | | | | | | | 1 | |
| 24 | 7 | | | | | | | | | | | | | |
| 25 | 7 | | | | | | | | | | | | | |

"The Need for a More Precise Definition of 'Algorithm'" -- Extended Dictionary

| Sentence Number | Number of Words | Total Number of Errors | Type-A Errors | Type-B Errors | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | NON | VRB | ADJ | ADV | PTC | DTR | PRN | PRP | INT | SUB | INF |
| 26 | 15 | 2 | | | 2 | | | | | | | | | |
| 27 | 23 | 1 | | | | 1 | | | | | | | | |
| 28 | 5 | | | | | | | | | | | | | |
| 29 | 19 | 3 | 1 | 1 | 2 | | | | | | | | | |
| 30 | 8 | | | | | | | | | | | | | |
| 31 | 22 | 2 | | 1 | 1 | | | | | | | | | |
| 32 | 10 | | | | | | | | | | | | | |
| 33 | 18 | 3 | | | 2 | 1 | | | | | | | | |
| 34 | 6 | | | | | | | | | | | | | |
| 35 | 21 | 2 | | | 2 | | | | | | | | | |
| 36 | 22 | 1 | 1 | | 1 | | | | | | | | | |
| 37 | 21 | 1 | | | | | 1 | | | | | | | |
| 38 | 8 | | | | | | | | | | | | | |
| 39 | 19 | 4 | 1 | 2 | | 1 | | | | | | 1 | | |
| 40 | 21 | 1 | | | | | | | | | 1 | | | |
| 41 | 15 | | | | | | | | | | | | | |
| 42 | 6 | | | | | | | | | | | | | |
| 43 | 18 | 2 | | 1 | 1 | | | | | | | | | |
| 44 | 35 | 2 | | | 1 | | 1 | | | | | | | |
| 45 | 22 | | | | | | | | | | | | | |
| 46 | 21 | 1 | | | 1 | | | | | | | | | |
| 47 | 30 | 2 | | 1 | 1 | | | | | | | | | |
| 48 | 19 | 3 | | 2 | | | 1 | | | | | | | |
| 49 | 24 | 1 | | | | | 1 | | | | | | | |
| 50 | 54 | 9 | 3 | 5 | | | 1 | 1 | | | | | | 2 |

"The Need for a More Precise Definition of 'Algorithm'" -- Extended Dictionary

| Sentence Number | Number of Words | Total Number of Errors | Type-A Errors | Type-B Errors | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | NON | VRB | ADJ | ADV | PTC | DTR | PRN | PRP | INT | SUB | INF |
| 51 | 43 | 5 | 1 | 4 | 1 | | | | | | | | | |
| 52 | 32 | 2 | | 1 | 1 | | | | | | | | | |
| 53 | 18 | | | | | | | | | | | | | |
| 54 | 8 | 1 | | 1 | | | | | | | | | | |
| 55 | 39 | 8 | | 5 | 1 | | | 2 | | | | | | |
| 56 | 9 | | | | | | | | | | | | | |
| 57 | 25 | 1 | | 1 | | | | | | | | | | |
| 58 | 45 | | | | | | | | | | | | | |
| 59 | 44 | 5 | | 3 | 2 | | | | | | | | | |
| 60 | 16 | 1 | | 1 | | | | | | | | | | |
| 61 | 23 | 2 | | 1 | | | 1 | | | | | | | |
| 62 | 29 | 2 | | | 1 | 1 | | | | | | | | |
| 63 | 27 | 5 | | 1 | | 2 | | | | | | 2 | | |
| 64 | 7 | 2 | 1 | | | 1 | | 1 | | | | | | |
| 65 | 21 | 1 | | | | | 1 | | | | | | | |
| 66 | 17 | 2 | 1 | | | | 2 | | | | | | | |
| 67 | 40 | | | | | | | | | | | | | |
| 68 | 24 | 2 | | | | 1 | 1 | | | | | | | |
| 69 | 24 | | | | | | | | | | | | | |
| 70 | 11 | | | | | | | | | | | | | |
| 71 | 31 | 2 | | | | 1 | | | | | | | | 1 |
| 72 | 45 | 2 | | | 2 | | | | | | | | | |
| 73 | 36 | 2 | | 1 | | | | 1 | | | | | | |
| 74 | 16 | 2 | | 1 | | | | 1 | | | | | | |
| 75 | 15 | | | | | | | | | | | | | |

"The Need for a More Precise Definition of 'Algorithm'" -- Extended Dictionary

| Sentence Number | Number of Words | Total Number of Errors | Type-A Errors | Type-B Errors | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | NON | VRB | ADJ | ADV | PTC | DTR | PRN | PRP | INT | SUB | INF |
| 76 | 37 | 1 | | | 1 | | | | | | | | | |
| 77 | 16 | 4 | | 1 | | 1 | 1 | | 1 | | | | | |
| 78 | 34 | 6 | | 3 | | 2 | 1 | | | | | | | |
| 79 | 39 | 2 | | | | 2 | | | | | | | | |
| 80 | 32 | 1 | | | | 1 | | | | | | | | |
| 81 | 10 | | | | | | | | | | | | | |
| 82 | 48 | 2 | | 1 | | 1 | | | | | | | | |
| 83 | 30 | 1 | 1 | | | | | | | | | | 1 | |
| 84 | 43 | | | | | | | | | | | | | |
| 85 | 51 | 5 | 1 | | 1 | | 1 | 1 | | | | | 1 | 1 |
| 86 | 25 | | | | | | | | | | | | | |
| 87 | 16 | 2 | 2 | 1 | | 1 | | | | | | | | |
| 88 | 16 | | | | | | | | | | | | | |
| 89 | 7 | | | | | | | | | | | | | |
| 90 | 16 | | | | | | | | | | | | | |
| 91 | 8 | | | | | | | | | | | | | |
| 92 | 30 | 2 | | 1 | | 1 | | | | | | | | |
| 93 | 42 | 6 | 4 | 1 | | 4 | 1 | | | | | | | |
| 94 | 22 | 2 | | | 1 | 1 | | | | | | | | |
| 95 | 22 | | | | | | | | | | | | | |
| 96 | 27 | 2 | | 1 | 1 | | | | | | | | | |
| 97 | 16 | 1 | | 1 | | | | | 1 | | | | | |
| TOTAL<br>% | 2231 | 157<br>7% | 20<br>6% | 52<br>33% | 32<br>20% | 27<br>17% | 24<br>15% | 8 | 1 | | 6 | 2 | 4 | 4 |

The Old Man and the Sea -- Basic Dictionary

| Sentence Number | Number of Words | Total Number of Errors | Type-A Errors | Type-B Errors |  |  |  |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  | NON | VRB | ADJ | ADV | PTC | DTR | PRN | PRP | INT | SUB | INF |
| 0 | 26 | 5 | 2 | 1 | 2 |  | 2 |  |  |  |  |  |  |  |
| 1 | 11 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 2 | 49 | 4 |  |  | 3 | 1 |  |  |  |  |  |  |  |  |
| 3 | 45 | 8 |  | 3 | 2 | 2 |  |  |  |  |  |  |  |  |
| 4 | 17 | 2 | 1 | 1 |  | 1 |  |  |  |  |  |  |  |  |
| 5 | 16 | 1 |  |  |  | 1 |  |  |  |  |  |  |  |  |
| 6 | 22 | 2 |  | 1 | 1 |  |  |  |  |  |  |  |  |  |
| 7 | 24 | 3 |  | 1 | 1 |  | 1 |  |  |  |  |  |  |  |
| 8 | 7 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 9 | 10 | 2 | 2 | 1 |  | 1 |  |  |  |  |  |  |  |  |
| 10 | 22 | 1 |  |  |  | 1 |  |  |  |  |  |  |  |  |
| 11 | 18 | 1 | 1 |  |  |  |  |  |  |  |  |  |  |  |
| 12 | 6 | 1 |  |  |  |  | 1 |  |  | 1 |  |  |  |  |
| 13 | 4 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 14 | 14 | 1 |  |  | 1 |  |  |  |  |  |  |  |  |  |
| 15 | 5 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 16 | 5 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 17 | 3 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 18 | 20 | 3 | 2 | 1 | 1 | 1 |  |  |  |  |  |  |  |  |
| 19 | 6 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 20 | 10 | 2 | 2 |  | 1 |  |  |  |  |  |  |  | 1 |  |
| 21 | 6 | 2 |  | 1 | 1 |  |  |  |  |  |  |  |  |  |
| 22 | 9 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 23 | 6 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 24 | 4 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 25 | 4 |  |  |  |  |  |  |  |  |  |  |  |  |  |

The Old Man and the Sea -- Basic Dictionary

| Sentence Number | Number of Words | Total Number of Errors | Type-A Errors | Type-B Errors | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | NON | VRB | ADJ | ADV | PTC | DTR | PRN | PRP | INT | SUB | INF |
| 26 | 5 | | | | | | | | | | | | | |
| 27 | 3 | | | | | | | | | | | | | |
| 28 | 2 | | | | | | | | | | | | | |
| 29 | 3 | | | | | | | | | | | | | |
| 30 | 16 | 3 | | 1 | 1 | | 1 | | | | | | | |
| 31 | 2 | | | | | | | | | | | | | |
| 32 | 4 | | | | | | | | | | | | | |
| 33 | 2 | 1 | | 1 | | | | | | | | | | |
| 34 | 21 | 2 | | 1 | 1 | | | | | | | | | |
| 35 | 11 | 1 | | | 1 | | | | | | | | | |
| 36 | 33 | 5 | 1 | 1 | 2 | 1 | 1 | | | | | | | |
| 37 | 53 | 4 | 3 | 2 | 1 | | | 1 | | | | | | |
| 38 | 42 | 14 | | | | | | | | | | | | |
| 39 | 17 | 14 | | 7 | 6 | 1 | | | | | | | | |
| 40 | 32 | 2 | | 1 | 1 | | | | | | | | | |
| 41 | 4 | | | | | | | | | | | | | |
| 42 | 5 | 1 | | | | | 1 | | | | | | | |
| 43 | 11 | | | | | | | | | | | | | |
| 44 | 11 | 1 | 1 | 1 | | | | | | | | | | |
| 45 | 7 | | | | | | | | | | | | | |
| 46 | 4 | 2 | | 1 | 1 | | | | | | | | | |
| 47 | 10 | 2 | | | 1 | | 1 | | | | | | | |
| 48 | 5 | | | | | | | | | | | | | |
| 49 | 14 | | | | | | | | | | | | | |
| 50 | 9 | | | | | | | | | | | | | |

The Old Man and the Sea -- Basic Dictionary

| Sentence Number | Number of Words | Total Number of Errors | Type-A Errors | Type-B Errors | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | NON | VRB | ADJ | ADV | PTC | DTR | PRN | PRP | INT | SUB | INF |
| 51 | 5 | | | | | | | | | | | | | |
| 52 | 12 | 2 | | | 1 | | 1 | | | | | | | |
| 53 | 22 | 5 | | 1 | 1 | 1 | 2 | | | | | | | |
| 54 | 3 | | | | | | | | | | | | | |
| 55 | 18 | 2 | 1 | 1 | | | | 1 | | | | | | |
| 56 | 41 | 5 | 2 | 2 | | 2 | | 1 | | | | | | |
| 57 | 13 | 4 | | | 2 | | 2 | | | | | | | |
| 58 | 9 | 2 | | | 1 | | 1 | | | | | | | |
| 59 | 12 | 5 | | 2 | 1 | 2 | | | | | | | | |
| 60 | 13 | 3 | 2 | 1 | 1 | | | | | | | | | |
| 61 | 15 | | | | | | | | | | | | | |
| 62 | 5 | | | | | | | | | | | | | |
| 63 | 9 | | | | | | | | | | | | | |
| 64 | 6 | 2 | | | 1 | | | | | 1 | | | | |
| 65 | 8 | | | | | | | | | | | | | |
| 66 | 6 | 1 | | | 1 | | | | | | | | | |
| 67 | 5 | | | | | | | | | | | | | |
| 68 | 8 | | | | | | | | | | | | | |
| 69 | 10 | | | | | | | | | | | | | |
| 70 | 4 | | | | | | | | | | | | | |
| 71 | 5 | | | | | | | | | | | | | |
| 72 | 4 | 1 | 1 | | 1 | | | | | | | | | |
| 73 | 5 | | | | | | | | | | | | | |
| 74 | 4 | | | | | | | | | | | | | |
| 75 | 6 | 1 | | | 1 | | | | | | | | | |

## *The Old Man and the Sea* -- Basic Dictionary

| Sentence Number | Number of Words | Total Number of Errors | Type-A Errors | Type-B Errors | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | NON | VRB | ADJ | ADV | PTC | DTR | PRN | PRP | INT | SUB | INF |
| 76 | 11 | 1 | | | | 1 | | | | | | | | |
| 77 | 22 | | | | | | | | | | | | | |
| 78 | 13 | | | | | | | | | | | | | |
| 79 | 4 | | | | | | | | | | | | | |
| 80 | 3 | | | | | | | | | | | | | |
| 81 | 9 | 2 | | 1 | 1 | | | | | | | | | |
| 82 | 9 | | | | | | | | | | | | | |
| 83 | 12 | 2 | | | 1 | | 1 | | | | | | | |
| 84 | 13 | 2 | | | | 1 | 1 | | | | | | | |
| 85 | 9 | 2 | | | 1 | | 1 | | | | | | | |
| 86 | 4 | | | | | | | | | | | | | |
| 87 | 22 | | | | | | | | | | | | | |
| 88 | 5 | 1 | | | | 1 | | | | | | | | |
| 89 | 4 | 1 | | | | 1 | | | | | | | | |
| 90 | 7 | | | | | | | | | | | | | |
| 91 | 4 | 2 | 2 | 1 | 1 | | | | | | | | | |
| 92 | [illegible] | 1 | | | 1 | | | | | | | | | |
| 93 | 15 | 1 | | 1 | | | | | | | | | | |
| 94 | 6 | | | | | | | | | | | | | |
| 95 | 11 | 1 | | | 1 | | | | | | | | | |
| 96 | 3 | 1 | 1 | | | | | | | | | 1 | | |
| TOTAL | 1135 | 137 | 24 | 36 | 46 | 19 | 17 | 3 | 0 | 1 | 1 | 1 | 1 | |
| % | | 12% | 10% | 26% | 33% | 14% | 12% | 2% | | 1% | 1% | 1% | 1% | |

## The Old Man and the Sea -- Extended Dictionary

| Sentence Number | Number of Words | Total Number of Errors | Type-A Errors | Type-B Errors | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | NON | VRB | ADJ | ADV | PTC | DTR | PRN | PRP | INT | SUB | INF |
| 0 | 26 | | | | | | | | | | | | | |
| 1 | 11 | | | | | | | | | | | | | |
| 2 | 49 | | | | | | | | | | | | | |
| 3 | 45 | 4 | | | | | | | | | | | | |
| 4 | 17 | 2 | 1 | 1 | | 1 | | | | | | | | |
| 5 | 16 | 1 | | | | 1 | | | | | | | | |
| 6 | 22 | 2 | | 1 | 1 | | | | | | | | | |
| 7 | 24 | 1 | 1 | | | | 1 | | | | | | | |
| 8 | 7 | | | | | | | | | | | | | |
| 9 | 10 | 2 | 2 | 1 | | 1 | | | | | | | | |
| 10 | 22 | 1 | | | | 1 | | | | | | | | |
| 11 | 18 | | | | | | | | | | | | | |
| 12 | 6 | | | | | | | | | | | | | |
| 13 | 4 | | | | | | | | | | | | | |
| 14 | 14 | 1 | | | 1 | | | | | | | | | |
| 15 | 5 | | | | | | | | | | | | | |
| 16 | 5 | | | | | | | | | | | | | |
| 17 | 3 | | | | | | | | | | | | | |
| 18 | 20 | 2 | | 1 | | 1 | | | | | | | | |
| 19 | 6 | | | | | | | | | | | | | |
| 20 | 10 | | | | | | | | | | | | | |
| 21 | 6 | 1 | | 1 | | | | | | | | | | |
| 22 | 9 | | | | | | | | | | | | | |
| 23 | 6 | | | | | | | | | | | | | |
| 24 | 4 | | | | | | | | | | | | | |
| 25 | 4 | | | | | | | | | | | | | |

## The Old Man and the Sea -- Extended Dictionary

| Sentence Number | Number of Words | Total Number of Errors | Type-A Errors | Type-B Errors | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | NON | VRB | ADJ | ADV | PTC | DTR | PRN | PRP | INT | SUB | INF |
| 26 | 5 | | | | | | | | | | | | | |
| 27 | 3 | | | | | | | | | | | | | |
| 28 | 2 | | | | | | | | | | | | | |
| 29 | 3 | | | | | | | | | | | | | |
| 30 | 16 | 2 | | 1 | | | 1 | | | | | | | |
| 31 | 2 | | | | | | | | | | | | | |
| 32 | 4 | | | | | | | | | | | | | |
| 33 | 2 | 1 | | | 1 | | | | | | | | | |
| 34 | 21 | | | | | | | | | | | | | |
| 35 | 11 | | | | | | | | | | | | | |
| 36 | 33 | 4 | 1 | 1 | 1 | 1 | 1 | | | | | | | |
| 37 | 53 | 2 | 2 | 1 | | | | | | | | | | |
| 38 | 48 | 13 | 2 | 7 | 5 | 1 | | | | | | | | |
| 39 | 17 | | | | | | | | | | | | | |
| 40 | 32 | 3 | 2 | 1 | | 2 | | | | | | | | |
| 41 | 4 | | | | | | | | | | | | | |
| 42 | 5 | 1 | | | | | 1 | | | | | | | |
| 43 | 11 | | | | | | | | | | | | | |
| 44 | 11 | 1 | 1 | 1 | | | | | | | | | | |
| 45 | 1 | | | | | | | | | | | | | |
| 46 | 4 | 2 | | 1 | 1 | | | | | | | | | |
| 47 | 10 | | | | | | | | | | | | | |
| 48 | 5 | 1 | 1 | | 1 | | | | | | | | | |
| 49 | 14 | 1 | 1 | | 1 | | | | | | | | | |
| 50 | 9 | | | | | | | | | | | | | |

### The Old Man and the Sea -- Extended Dictionary

| Sentence Number | Number of Words | Total Number of Errors | Type-A Errors | Type-B Errors | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | NON | VRB | ADJ | ADV | PTC | DTR | PRN | PRP | INT | SUB | INF |
| 51 | 5 | | | | | | | | | | | | | |
| 52 | 12 | 1 | | | | 1 | | | | | | | | |
| 53 | 22 | 3 | | 1 | 1 | 1 | | | | | | | | |
| 54 | 3 | | | | | | | | | | | | | |
| 55 | 18 | 1 | | 1 | | | | | | | | | | |
| 56 | 6 | 2 | | 1 | 3 | | | | | | | | | |
| 57 | 13 | | | | | | | | | | | | | |
| 58 | 9 | | | | | | | | | | | | | |
| 59 | 12 | 1 | | | | 1 | | | | | | | | |
| 60 | 13 | 3 | | 1 | 2 | | | | | | | | | |
| 61 | 15 | | | | | | | | | | | | | |
| 62 | 5 | | | | | | | | | | | | | |
| 63 | 9 | | | | | | | | | | | | | |
| 64 | 6 | 1 | | | 1 | | | | | | | | | |
| 65 | 8 | | | | | | | | | | | | | |
| 66 | 6 | 1 | | | | 1 | | | | | | | | |
| 67 | 5 | | | | | | | | | | | | | |
| 68 | 8 | | | | | | | | | | | | | |
| 69 | 10 | | | | | | | | | | | | | |
| 70 | 4 | | | | | | | | | | | | | |
| 71 | 5 | | | | | | | | | | | | | |
| 72 | 4 | 1 | | | 1 | | | | | | | | | |
| 73 | 5 | | | | | | | | | | | | | |
| 74 | 4 | | | | | | | | | | | | | |
| 75 | 6 | | | | | | | | | | | | | |

The Old Man and the Sea -- Extended Dictionary

| Sentence Number | Number of Words | Total Number of Errors | Type-A Errors | Type-B Errors | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | NON | VRB | ADJ | ADV | PTC | DTR | PRN | PRP | INT | SUB | INF |
| 76 | 11 | | | | | | | | | | | | | |
| 77 | 22 | | | | | | | | | | | | | |
| 78 | 13 | | | | | | | | | | | | | |
| 79 | 4 | | | | | | | | | | | | | |
| 80 | 3 | | | | | | | | | | | | | |
| 81 | 9 | 2 | | 1 | 1 | | | | | | | | | |
| 82 | 9 | | | | | | | | | | | | | |
| 83 | 12 | 3 | 1 | | 2 | | 1 | | | | | | | |
| 84 | 13 | 2 | | | | 1 | 1 | | | | | | | |
| 85 | 9 | 2 | 1 | | 1 | | 1 | | | | | | | |
| 86 | 4 | | | | | | | | | | | | | |
| 87 | 22 | | | | | | | | | | | | | |
| 88 | 5 | 1 | | | | 1 | | | | | | | | |
| 89 | 4 | | | | | | | | | | | | | |
| 90 | 7 | | | | | | | | | | | | | |
| 91 | 4 | 1 | | 1 | | | | | | | | | | |
| 92 | 6 | 1 | | | 1 | | | | | | | | | |
| 93 | 15 | 1 | | 1 | | | | | | | | | | |
| 94 | 6 | | | | | | | | | | | | | |
| 95 | 11 | 1 | | | | 1 | | | | | | | | |
| 96 | 3 | 1 | 1 | | | | | | | | | 1 | | |
| TOTAL | 1135 | 78 | 17 | 26 | 23 | 19 | 7 | 1 | 0 | 0 | 0 | 1 | | |
| % | | 7% | 5% | 33% | 30% | 24% | 9% | 1% | | | | 1% | | |

"The Clavichord and How to Play It" -- Basic Dictionary

| Sentence Number | Number of Words | Total Number of Errors | Type-A Errors | Type-B Errors | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | NON | VRB | ADJ | ADV | PTC | DTR | PRN | PRP | INT | SUB | INF |
| 1 | 7 | | | | | | | | | | | | | |
| 2 | 27 | 2 | | | | 2 | | | | | | | | |
| 3 | 25 | 3 | 1 | | 1 | | 2 | | | | | | | |
| 4 | 18 | 5 | | 2 | 2 | | 1 | | | | | | | |
| 5 | 27 | 4 | | 2 | 1 | | | 1 | | | | | | |
| 6 | 8 | 3 | | 1 | 1 | 1 | | | | | | | | |
| 7 | 17 | 1 | | | | | 1 | | | | | | | |
| 8 | 27 | 6 | 1 | 1 | 1 | 3 | | | | | | | | |
| 9 | 18 | 6 | 2 | 3 | 2 | | 1 | | | | | | | |
| 10 | 32 | 6 | | 1 | 3 | | 1 | 1 | | | | | | |
| 11 | 27 | 5 | | 2 | 1 | 1 | 1 | | | | | | | |
| 12 | 21 | 1 | | | | | 1 | | | | | | | |
| 13 | 7 | 3 | | | | 2 | 1 | | | | | | | |
| 14 | 33 | 4 | 1 | 1 | 2 | 1 | | | | | | | | |
| 15 | 41 | 3 | 1 | 2 | | | | | | | | | | |
| 16 | 13 | | | | | | | | | | | | | |
| 17 | 18 | 1 | | | 1 | | | | | | | | | |
| 18 | 17 | 2 | | | | 1 | 1 | | | | | | | |
| 19 | 33 | 6 | 1 | 1 | 1 | 3 | | | | | | | 1 | |
| 20 | 22 | 4 | 1 | 2 | | 1 | 1 | | | | | | | |
| 21 | 15 | 1 | 1 | | 1 | | | | | | | | | |
| 22 | 17 | 1 | 1 | | | | 1 | | | | | | | |
| 23 | 29 | 6 | 1 | 1 | 2 | | 1 | | 2 | | | | | |
| 24 | 18 | 1 | | | 1 | | | | | | | | | |
| 25 | 21 | 3 | 3 | | | 3 | | | | | | | | |

"The Clavichord and How to Play It" -- Basic Dictionary

| Sentence Number | Number of Words | Total Number of Errors | Type-A Errors | Type-B Errors NON | VRB | ADJ | ADV | PTC | DTR | PRN | PRP | INT | SUB | INF |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 26 | 20 | 4 |  | 2 | 1 | 1 |  |  |  |  |  |  |  |  |
| 27 | 25 | 4 |  | 2 | 2 |  |  |  |  |  |  |  |  |  |
| 28 | 24 | 1 | 1 |  | 1 |  |  |  |  |  |  |  |  |  |
| 29 | 20 | 7 |  | 1 | 2 | 3 |  |  | 1 |  |  |  |  |  |
| 30 | 10 | 4 |  | 1 | 1 |  | 1 | 1 |  |  |  |  |  |  |
| 31 | 14 | 3 |  | 1 |  |  | 2 |  |  |  |  |  |  |  |
| 32 | 26 | 3 |  |  |  | 1 | 2 |  |  |  |  |  |  |  |
| 33 | 28 | 5 | 2 |  | 2 | 1 | 2 |  |  |  |  |  |  |  |
| 34 | 38 | 4 | 2 |  | 2 | 1 |  |  |  |  |  | 1 |  |  |
| 35 | 8 | 2 |  |  |  | 2 |  |  |  |  |  |  |  |  |
| 36 | 13 | 1 |  |  | 1 |  |  |  |  |  |  |  |  |  |
| 37 | 51 | 1 |  |  |  |  |  | 1 |  |  |  |  |  |  |
| 38 | 12 | 2 | 1 |  |  |  | 2 |  |  |  |  |  |  |  |
| 39 | 25 | 5 | 1 | 1 | 1 | 1 | 1 | 1 |  |  |  |  |  |  |
| 40 | 24 | 2 |  |  |  | 1 |  |  |  |  | 1 |  |  |  |
| 41 | 36 | 1 |  |  | 1 |  |  |  |  |  |  |  |  |  |
| 42 | 12 | 3 |  | 1 | 2 |  |  |  |  |  |  |  |  |  |
| 43 | 28 | 11 |  | 4 | 3 | 2 | 1 |  |  |  |  |  |  |  |
| 44 | 25 | 4 | 1 | 1 | 1 |  | 1 |  |  |  | 1 |  |  |  |
| 45 | 14 | 3 |  | 1 |  | 1 |  |  |  | 1 |  |  |  |  |
| 46 | 20 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 47 | 14 | 1 |  |  | 1 |  |  |  |  |  |  |  |  |  |
| 48 | 20 | 2 |  | 1 | 1 |  |  |  |  |  |  |  |  |  |
| 49 | 27 | 1 |  |  | 1 |  |  |  |  |  |  |  |  |  |
| 50 | 34 | 4 | 1 | 1 | 2 |  | 1 |  |  |  |  |  |  |  |

## "The Clavichord and How to Play It" -- Basic Dictionary

| Sentence Number | Number of Words | Total Number of Errors | Type-A Errors | Type-B Errors |  |  |  |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  | NON | VRB | ADJ | ADV | PTC | DTR | PRN | PRP | INT | SUB | INF |
| 51 | 30 | 5 |  | 2 | 3 |  |  |  |  |  |  |  |  |  |
| 52 | 18 | 1 |  |  |  | 1 |  |  |  |  |  |  |  |  |
| 53 | 17 | 3 |  | 1 | 1 |  |  | 1 |  |  |  |  |  |  |
| 54 | 6 | 1 |  |  |  | 1 |  |  |  |  |  |  |  |  |
| 55 | 38 | 5 |  |  | 1 |  |  |  |  |  |  |  |  |  |
| 56 | 24 | 6 |  | 2 | 2 |  | 3 |  |  |  |  |  |  |  |
| 57 | 16 | 1 |  |  | 1 |  |  |  |  |  |  |  |  |  |
| 58 | 18 | 1 |  |  |  |  | 1 |  |  |  |  |  |  |  |
| 59 | 38 | 5 |  | 3 | 2 |  |  |  |  |  |  |  |  |  |
| 60 | 8 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 61 | 20 | 2 |  | 1 | 1 |  |  |  |  |  |  |  |  |  |
| 62 | 20 | 2 |  | 1 |  | 1 |  |  |  |  |  |  |  |  |
| 63 | 24 | 3 | 1 | 1 |  | 2 |  |  |  |  |  |  |  |  |
| 64 | 33 | 10 |  | 4 | 1 | 1 | 1 | 4 |  |  |  |  |  |  |
| 65 | 28 | 4 |  | 1 | 1 | 2 |  |  |  |  |  |  |  |  |
| 66 | 31 | 5 | 1 | 2 | 2 | 1 |  |  |  |  |  |  |  |  |
| 67 | 22 | 5 |  | 2 | 1 | 2 |  |  |  |  |  |  |  |  |
| 68 | 42 | 7 |  | 1 | 3 | 2 | 1 |  |  |  |  |  |  |  |
| 69 | 43 | 6 | 1 | 1 | 2 | 3 |  |  |  |  |  |  |  |  |
| 70 | 21 | 3 |  |  |  | 2 | 1 |  |  |  |  |  |  |  |
| 71 | 29 | 5 | 1 | 1 | 2 | 3 |  |  |  |  |  |  |  |  |
| 72 | 23 | 3 | 1 | 1 | 1 |  |  | 1 |  |  |  |  |  |  |
| 73 | 15 | 1 | 1 |  |  |  |  |  |  |  |  | 1 |  |  |
| 74 | 28 | 3 | 1 | 1 | 1 |  | 1 |  |  |  |  |  |  |  |
| 75 | 14 | 2 |  |  | 1 |  | 1 |  |  |  |  |  |  |  |
| TOTAL<br>% | 2620 | 243<br>9% | 30<br>8% | 61<br>25% | 70<br>28% | 53<br>21% | 38<br>16% | 10<br>4% | 3<br>1% | 0 | 1<br>.4% | 3<br>1% | 2<br>.8% | 0 |

"The Clavichord and How to Play It" -- Extended Dictionary

| Sentence Number | Number of Words | Total Number of Errors | Type-A Errors | Type-B Errors | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | NON | VRB | ADJ | ADV | PTC | DTR | PRN | PRP | INT | SUB | INF |
| 1 | 7 | | | | | | | | | | | | | |
| 2 | 27 | | | | | | | | | | | | | |
| 3 | 25 | 3 | | | 1 | | 2 | | | | | | | |
| 4 | 18 | 3 | | 1 | 1 | | | | | | | | | |
| 5 | 27 | 4 | | 2 | | | 1 | 1 | | | | | | |
| 6 | 8 | 3 | | 1 | 1 | 1 | | | | | | | | |
| 7 | 17 | 2 | 1 | | 1 | 1 | | | | | | | | |
| 8 | 27 | 5 | | 1 | 1 | 3 | | | | | | | | |
| 9 | 18 | 6 | 2 | 2 | 3 | 1 | | | | | | | | |
| 10 | 32 | 5 | | 1 | 4 | | | | 1 | | | | | |
| 11 | 27 | 5 | | 2 | 1 | 1 | 1 | | | | | | | |
| 12 | 21 | 1 | | | | | 1 | | | | | | | |
| 13 | 7 | 2 | | | | | 1 | | | | | | | |
| 14 | 33 | 4 | | 1 | 2 | | 1 | | | | | | | |
| 15 | 41 | 1 | | | | | | 1 | | | | | | |
| 16 | 13 | 1 | | | 1 | | | | | | | | | |
| 17 | 18 | 2 | | | 1 | 1 | | | | | | | | |
| 18 | 7 | 2 | | 1 | | 1 | | | | | | | | |
| 19 | 33 | 6 | | 1 | 1 | 4 | | | | | | | | |
| 20 | 22 | 4 | 1 | | | 4 | | | | | | | | |
| 21 | 15 | | | | | | | | | | | | | |
| 22 | 17 | 2 | | | | | 1 | | | | | | | 1 |
| 23 | 29 | 3 | | 2 | | | 1 | | | | | | | |
| 24 | 18 | | | | | | | | | | | | | |
| 25 | 21 | 4 | 3 | | 1 | 3 | | | | | | | | |

"The Clavichord and How to Play It" -- Extended Dictionary

| Sentence Number | Number of Words | Total Number of Errors | Type-A Errors | Type-B Errors | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | NON | VRB | ADJ | ADV | PTC | DTR | PRN | PRP | INT | SUB | INF |
| 26 | 20 | | | | | | | | | | | | | |
| 27 | 25 | 4 | | 2 | 2 | | | | | | | | | |
| 28 | 24 | | | | | | | | | | | | | |
| 29 | 20 | 3 | | | | 3 | | | | | | | | |
| 30 | 10 | 2 | | 1 | 1 | | | | | | | | | |
| 31 | 14 | 1 | | | | | 1 | | | | | | | |
| 32 | 26 | 3 | | | | 2 | 1 | | | | | | | |
| 33 | 28 | 3 | | | 1 | 2 | | | | | | | | |
| 34 | 38 | 2 | | | | 1 | | | | | | | | |
| 35 | 8 | 1 | | 1 | | | | | | | | | | |
| 36 | 13 | 1 | | | | | | | | | | | | |
| 37 | 51 | 1 | | | | | | 1 | | | | | | |
| 38 | 12 | 1 | | | | | 1 | | | | | | | |
| 39 | 25 | 5 | 1 | 1 | 2 | | 1 | 1 | | | | | | |
| 40 | 24 | 2 | 1 | | | 1 | | | | | | | | 1 |
| 41 | 36 | | | | | | | | | | | | | |
| 42 | 12 | 2 | | | 1 | | 1 | | | | | | | |
| 43 | 14 | 3 | | 1 | | 2 | | | | | | | | |
| 44 | 28 | 8 | 2 | 2 | 3 | 1 | 2 | | | | | | | |
| 45 | 25 | 5 | 2 | 1 | 1 | | 1 | | | 1 | | | | 1 |
| 46 | 14 | 1 | | | | | | | | | | | | 1 |
| 47 | 20 | 2 | | 1 | 1 | | | | | | | | | |
| 48 | 14 | 1 | | | | | | | | | | | | |
| 49 | 27 | | | | | | | | | | | | | |
| 50 | 34 | 1 | 1 | 1 | | | | | | | | | | |

"The Clavichord and How to Play It" -- Extended Dictionary

5

| Sentence Number | Number of Words | Total Number of Errors | Type-A Errors | Type-B Errors | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | NON | VRB | ADJ | ADV | PTC | DTR | PRN | PRP | INT | SUB | INF |
| 51 | 30 | 4 | | 2 | 2 | | | | | | | | | |
| 52 | 18 | 2 | | | | 2 | | | | | | | | |
| 53 | 17 | 1 | | | 1 | | | | | | | | | |
| 54 | 6 | 1 | | | | 1 | | | | | | | | |
| 55 | 38 | 5 | 2 | 1 | 1 | 1 | 1 | | | | | | 1 | |
| 56 | 24 | 1 | | | | | 1 | | | | | | | |
| 57 | 16 | 1 | | | | 1 | 1 | | | | | | | |
| 58 | 18 | 1 | | | | | | | | | | | | |
| 59 | 38 | 5 | | 2 | 1 | 2 | | | | | | | | |
| 60 | 8 | | | | | | | | | | | | | |
| 61 | 20 | 2 | | 1 | | | 1 | | | | | | | |
| 62 | 20 | | | | | | | | | | | | | |
| 63 | 24 | 3 | 1 | 1 | | 1 | | | | | | | | |
| 64 | 33 | 7 | | 2 | | 1 | 1 | | | | | | | |
| 65 | 28 | 4 | | 1 | | 1 | | 1 | | | | | | |
| 66 | 31 | 6 | 1 | 2 | 2 | 2 | | | | | | | | |
| 67 | 22 | | | | | | | | | | | | | |
| 68 | 42 | 7 | | 1 | 2 | 2 | 1 | | | | | | | 1 |
| 69 | 43 | 7 | 3 | 1 | 1 | 1 | 3 | | | | | 1 | | |
| 70 | 21 | 4 | | | | 3 | 1 | | | | | | | |
| 71 | 29 | 3 | 1 | | | 2 | | | | | | | | |
| 72 | 23 | 2 | | 1 | | | | | 1 | | | | | |
| 73 | 15 | | | | | | | | | | | | | |
| 74 | 28 | 2 | | 1 | 1 | | | | | | | | | |
| 75 | 14 | 2 | | | 1 | | 1 | | | | | | | |
| TOTAL | 2620 | 190 | 22 | 40 | 45 | 56 | 29 | 8 | 2 | 1 | 1 | 3 | 4 | 3 |
| % | | 7% | 6% | 21% | 24% | 29% | 15% | 4% | 1% | .5% | .5% | 2% | 2% | 2% |

# APPENDIX E

# APPENDIX E. DETAILED ERROR ANALYSIS OF DOCUMENTS ANALYZED BY CAP/I AND PAP.

"The Need for a More Precise Definition of 'Algorithm'"

| Sentence Number | Correct Number of Clauses | Number of Clauses not Identified | Number of Clauses Improperly Delimited | Correct Number of Phrases | Number of Phrases Improperly Delimited | Phrases Incorrectly Identified | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Total | Errors By Phrase Type | | | | | |
| | | | | | | | NOMP | VRBP | PRPP | ADJP | ADVP | Other |
| 1 | 1 | | | 3 | 1 | 1 | 1 | | | | | |
| 2 | | | | | | | | | | | | |
| 3 | | | | | | | | | | | | |
| 4 | 3 | 1 | 1 | 9 | 1 | 3 | 1 | 2 | | | | |
| 5 | 2 | | 2 | 7 | 1 | | | | | | | |
| 6 | 3 | | 1 | 13 | 2 | 3 | | | 1 | 1 | | |
| 7 | 1 | | | 3 | | | | | | | | |
| 8 | 5 | 1 | 1 | 15 | 2 | | | | | | | |
| 9 | 3 | | | 11 | 1 | 1 | | | | | | 1 |
| 10 | 3 | | 1 | 11 | | | | | | | | |
| 11 | 1 | | | 3 | | | | | | | | |
| 12 | 4 | | 2 | 11 | 1 | | | | | | | |
| 13 | 3 | 2 | 2 | 16 | 1 | 1 | | | | | 1 | |
| 14 | 4 | 1 | 1 | 18 | 1 | 1 | | | | 1 | | |
| 15 | 3 | 1 | 2 | 10 | | | | | | | | |
| 16 | 1 | | | 12 | 2 | 1 | | 1 | | | | |
| 17 | 2 | | 1 | 14 | 2 | | | | | | | |
| 18 | 1 | | 1 | 8 | 1 | 1 | | 1 | | | | |
| 19 | 4 | | | 24 | 4 | 2 | | 1 | | | 1 | |
| 20 | 3 | 2 | 1 | 21 | | | | | | | | |
| 21 | 3 | | 1 | 12 | 1 | | | | | | | |
| 22 | 3 | 1 | 2 | 9 | | 1 | | 1 | | | | |
| 23 | 3 | 1 | 1 | 7 | 1 | 2 | 1 | 2 | | | | |
| 24 | 2 | | | 5 | | | | | | | | |
| 25 | 2 | | | 4 | | | | | | | | |

"The Need for a More Precise Definition of 'Algorithm'"

| Sentence Number | Correct Number of Clauses | Number of Clauses not Identified | Number of Clauses Improperly Delimited | Correct Number of Phrases | Number of Phrases Improperly Delimited | Phrases Incorrectly Identified | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Total | Errors By Phrase Type | | | | | |
| | | | | | | | NOMP | VRBP | PRPP | ADJP | ADVP | Other |
| 26 | 2 | 1 | 1 | 6 | 1 | | | | | | | |
| 27 | 5 | 2 | 3 | 16 | | | | | | | | |
| 28 | 1 | | | 3 | | | | | | | | |
| 29 | 4 | 2 | 1 | 8 | 1 | 2 | | 2 | | | | |
| 30 | 1 | | | 3 | 1 | | | | | | | |
| 31 | 3 | | | 10 | | 1 | | 1 | | | | |
| 32 | 1 | | 1 | 3 | 1 | 1 | | | | 1 | | |
| 33 | 1 | | 1 | 6 | 3 | 2 | 1 | 1 | | | | |
| 34 | 1 | | | 3 | | | | | | | | |
| 35 | 3 | 1 | 1 | 8 | 1 | 2 | 1 | 1 | | | | |
| 36 | 3 | 1 | 1 | 11 | 1 | 1 | | | | | 1 | |
| 37 | 3 | 2 | 1 | 10 | 1 | | | | | | | |
| 38 | 2 | | | 5 | | | | | | | | |
| 39 | 2 | | 1 | 10 | 2 | 3 | 1 | | 1 | 1 | | |
| 40 | 3 | | 1 | 11 | 2 | 1 | | | 1 | | | |
| 41 | 2 | 1 | 1 | 6 | | | | | | | | |
| 42 | 1 | | | 3 | | | | | | | | |
| 43 | 2 | | 1 | 7 | 2 | 1 | | 1 | | | | |
| 44 | 5 | 1 | 2 | 21 | | | | | | | | |
| 45 | 1 | | 1 | 9 | | | | | | | | |
| 46 | 2 | | | 9 | 1 | | | | | | | |
| 47 | 4 | 1 | 1 | 13 | 1 | 1 | | 1 | | | | |
| 48 | 2 | | 1 | 10 | 2 | 3 | 2 | | | | 1 | |
| 49 | 3 | 1 | 1 | 9 | | | | | | | | |
| 50 | 4 | | 1 | 24 | 6 | 7 | 2 | 2 | 2 | | 1 | |

| Sentence Number | Correct Number of Clauses | Number of Clauses not Identified | Number of Clauses Improperly Delimited | Correct Number of Phrases | Number of Phrases Improperly Delimited | Phrases Incorrectly Identified |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  |  |  | Total | Errors By Phrase Type |  |  |  |  |  |
|  |  |  |  |  |  |  | NOMP | VRBP | PRPP | ADJP | ADVP | Other |
| 51 | 2 |  | 1 | 15 | 1 | 2 |  | 1 | 1 |  |  |  |
| 52 | 3 |  | 1 | 14 | 2 | 2 | 1 | 1 |  |  |  |  |
| 53 | 1 |  |  | 5 |  |  |  |  |  |  |  |  |
| 54 | 1 |  | 1 | 4 |  |  |  |  |  |  |  |  |
| 55 | 1 |  |  | 14 | 5 | 3 | 2 | 3 |  |  |  |  |
| 56 | 2 |  |  | 4 | 1 |  |  |  |  |  |  |  |
| 57 | 2 |  | 1 | 9 | 1 |  |  |  |  |  |  |  |
| 58 | 6 |  | 2 | 21 |  |  |  |  |  |  |  |  |
| 59 | 6 | 2 | 1 | 24 | 1 | 2 |  | 2 |  |  |  |  |
| 60 | 2 |  |  | 7 |  |  |  |  |  |  |  |  |
| 61 | 3 |  | 1 | 12 |  |  |  |  |  |  |  |  |
| 62 | 3 |  |  | 15 | 2 | 2 |  | 1 |  | 1 |  |  |
| 63 | 3 | 2 | 1 | 16 | 3 | 3 |  | 1 |  | 2 |  |  |
| 64 | 2 | 1 | 1 | 5 |  |  |  |  | 1 |  |  |  |
| 65 | 3 |  | 1 | 8 | 1 | 1 |  |  |  |  | 1 |  |
| 66 | 2 |  | 1 | 9 | 2 |  |  |  | 1 |  | 1 |  |
| 67 | 7 | 2 | 2 | 24 |  | 1 |  |  |  | 1 |  |  |
| 68 | 3 |  | 1 | 11 | 2 | 1 |  |  |  |  | 1 |  |
| 69 | 3 |  |  | 13 |  |  |  |  |  |  |  |  |
| 70 | 1 |  |  | 4 |  |  |  |  |  |  |  |  |
| 71 | 3 |  | 1 | 21 | 2 | 3 |  | 1 |  | 1 | 1 |  |
| 72 | 6 |  |  | 24 | 2 |  |  |  |  |  |  |  |
| 73 | 5 | 1 | 2 | 14 | 3 | 2 | 1 | 1 |  |  |  |  |
| 74 | 4 | 2 | 1 | 8 | 2 | 2 | 1 | 1 |  |  |  |  |
| 75 | 2 |  |  | 8 |  |  |  |  |  |  |  |  |

"The Need for a More Precise Definition of 'Algorithm'"

| Sentence Number | Correct Number of Clauses | Number of Clauses not Identified | Number of Clauses Improperly Delimited | Correct Number of Phrases | Number of Phrases Improperly Delimited | Phrases Incorrectly Identified | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Total | Errors By Phrase Type | | | | | |
| | | | | | | | NOMP | VRBP | PRPP | ADJP | ADVP | Other |
| 76 | 3 | 1 | 1 | 14 | 1 | 1 | | 1 | | | | |
| 77 | 2 | | | 7 | 1 | 2 | 1 | 1 | | | | |
| 78 | 2 | | | 12 | 2 | | | | | | | |
| 79 | 3 | | 3 | 15 | 1 | | | | | | | |
| 80 | 5 | 4 | 1 | 12 | | | | | | | | |
| 81 | 1 | | | | | | | | | | | |
| 82 | 5 | 1 | 2 | 23 | 2 | 1 | | 1 | | | | |
| 83 | 2 | | 1 | 12 | | | | | | | | |
| 84 | 4 | | 3 | 18 | | 1 | | | | | | 1 |
| 85 | 6 | 1 | 2 | 26 | 5 | 2 | | 1 | | | 1 | |
| 86 | 3 | | | 13 | | 1 | | | | 1 | | |
| 87 | 2 | | | 5 | 1 | 1 | | | 1 | | | |
| 88 | 2 | | 1 | 12 | | | | | | | | |
| 39 | 1 | | | 3 | | | | | | | | |
| 90 | 2 | 1 | 1 | 8 | | | | | | | | |
| 91 | 2 | | | 6 | | | | | | | | |
| 92 | 2 | | | 13 | 2 | 2 | 1 | | 1 | | | |
| 93 | 4 | 2 | 1 | 18 | 2 | 3 | | | 2 | | 1 | |
| 94 | 2 | | | 6 | 1 | | | | | | | |
| 95 | 3 | | | 10 | 1 | | | | | | | |
| 96 | 3 | | | 11 | 2 | 2 | 1 | 1 | | | | |
| 97 | 1 | | | 5 | 1 | | | | | | | |
| TOTAL<br>% | 237 | 43<br>18% | 79<br>41% | 1028 | 104<br>10% | 85<br>8% | 17<br>20% | 35<br>41% | 11<br>13% | 10<br>18% | 1<br>1% | 10<br>14% |

## The Old Man and the Sea

| Sentence Number | Correct Number of Clauses | Number of Clauses not Identified | Number of Clauses Improperly Delimited | Correct Number of Phrases | Number of Phrases Improperly Delimited | Phrases Incorrectly Identified | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Total | Errors By Phrase Type | | | | | |
| | | | | | | | NOMP | VRBP | PRPP | ADJP | ADVP | Other |
| 0 | 4 | 2 | 1 | 13 | | | | | | | | |
| 1 | 1 | | | 4 | | | | | | | | |
| 2 | 5 | 1 | 1 | 21 | | 2 | | 1 | | 1 | | |
| 3 | 7 | 2 | 1 | 20 | 1 | | | | | | | |
| 4 | 3 | | 1 | 8 | | 1 | | | | 1 | | |
| 5 | 1 | | | 6 | 2 | 2 | | | 1 | 1 | | |
| 6 | 3 | 2 | 1 | 7 | 1 | 1 | | 1 | | | | |
| 7 | 3 | | | 12 | 1 | | | | | | | |
| 8 | 1 | | | 4 | | | | | | | | |
| 9 | 2 | | | 5 | 1 | 2 | | | 1 | 1 | | |
| 10 | 3 | 1 | 13 | 2 | 1 | | | | | | | |
| 11 | 3 | 1 | 1 | 12 | | 1 | | | 1 | | | |
| 12 | 1 | | | 4 | | | | | | | | |
| 13 | 1 | | | 3 | | | | | | | | |
| 14 | 3 | | | 8 | 1 | | | | | | | |
| 15 | 1 | | 1 | 3 | | | | | | | | |
| 16 | 1 | | | 2 | | | | | | | | |
| 17 | 1 | | | 2 | | | | | | | | |
| 18 | 3 | | | 14 | 2 | | | | | | | |
| 19 | 2 | | | 4 | | | | | | | | |
| 20 | 2 | | | 8 | 1 | | | | | | | |
| 21 | 2 | 1 | 1 | 6 | | 1 | 1 | | | | | |
| 22 | 2 | | | 7 | | | | | | | | |
| 23 | 2 | | | 4 | | | | | | | | |
| 24 | 1 | | | 3 | | | | | | | | |
| 25 | 1 | | | 3 | | | | | | | | |

The Old Man and the Sea

| Sentence Number | Correct Number of Clauses | Number of Clauses not Identified | Number of Clauses Improperly Delimited | Correct Number of Phrases | Number of Phrases Improperly Delimited | Phrases Incorrectly Identified | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Total | Errors By Phrase Type | | | | | |
| | | | | | | | NOMP | VRBP | PRPP | ADJP | ADVP | Other |
| 26 | 1 | | 1 | 3 | | | | | | | | |
| 27 | 1 | | | 3 | | | | | | | | |
| 28 | 1 | | | 2 | | | | | | | | |
| 29 | 1 | | | 2 | | | | | | | | |
| 30 | 2 | | | 10 | | | | | | | | |
| 31 | 1 | | | 1 | | | | | | | | |
| 32 | 1 | | | 2 | | | | | | | | |
| 33 | 1 | | | 1 | | 1 | | | 1 | | | |
| 34 | 3 | | | 10 | 1 | | | | | | | |
| 35 | 2 | | 1 | 6 | 1 | | | | | | | |
| 36 | 4 | | 1 | 21 | 3 | 1 | | | | | 1 | |
| 37 | 6 | 1 | 1 | 25 | 1 | 1 | | | | | 1 | |
| 38 | 8 | 4 | 5 | 29 | 5 | 6 | 1 | 5 | | | | |
| 39 | 2 | 1 | 1 | 8 | | | | | | | | |
| 40 | 4 | | 1 | 19 | 2 | | | | | | | |
| 41 | 1 | | 1 | 3 | | | | | | | | |
| 42 | 1 | | 1 | 3 | | 1 | | | | | 1 | |
| 43 | 2 | | | 6 | | | | | | | | |
| 44 | 2 | | | 8 | | 1 | 1 | | | | | |
| 45 | 1 | | | 1 | | | | | | | | |
| [illegible] | 1 | | 1 | 2 | 1 | 2 | 1 | 1 | | | | |
| [illegible] | 2 | | | 6 | 1 | | | | | | | |
| 48 | 2 | | | 3 | 1 | | | | | | | |
| 49 | 3 | | | 8 | 1 | | | | | | | |
| 50 | 2 | | | 6 | | | | | | | | |

The Old Man and the Sea

| Sentence Number | Correct Number of Clauses | Number of Clauses not Identified | Number of Clauses Improperly Delimited | Correct Number of Phrases | Number of Phrases Improperly Delimited | Phrases Incorrectly Identified | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Total | Errors By Phrase Type | | | | | |
| | | | | | | | NOMP | VRBP | PRPP | ADJP | ADVP | Other |
| 51 | 1 | | | 4 | | | | | | | | |
| 52 | 2 | | | 10 | | 2 | | | | 1 | 1 | |
| 53 | 3 | | | 16 | 1 | 1 | | | | 1 | | |
| 54 | 1 | | | 3 | | | | | | | | |
| 55 | 2 | | 1 | 10 | | 2 | | 2 | | | | |
| 56 | 7 | 2 | 4 | 25 | 3 | | | | | | | |
| 57 | 2 | | | 9 | 2 | | | | | | | |
| 58 | 2 | | | 9 | | | | | | | | |
| 59 | 1 | | | 4 | | | | | | | | |
| 60 | 4 | 2 | 1 | 11 | 1 | 2 | 1 | 1 | | | | |
| 61 | 2 | | 1 | 10 | | | | | | | | |
| 62 | 1 | | | 4 | | | | | | | | |
| 63 | 2 | | | 7 | | | | | | | | |
| 64 | 2 | 1 | 1 | 5 | 1 | 1 | | 1 | | | | |
| 65 | 1 | | | 5 | | | | | | | | |
| 66 | 1 | | | 4 | 1 | | | | | | | |
| 67 | 1 | | | 3 | | | | | | | | |
| 68 | 1 | | | 3 | 1 | | | | | | | |
| 69 | 2 | | | 8 | | | | | | | | |
| 70 | 1 | | 1 | 3 | | | | | | | | |
| 71 | 1 | | 1 | 3 | | | | | | | | |
| 72 | 1 | | | 3 | 1 | | | | | | | |
| 73 | 2 | | | 4 | | | | | | | | |
| 74 | 1 | | | 4 | | | | | | | | |
| 75 | 2 | | | 4 | | 1 | | 1 | | | | |

## The Old Man and the Sea

| Sentence Number | Correct Number of Clauses | Number of Clauses not Identified | Number of Clauses Improperly Delimited | Correct Number of Phrases | Number of Phrases Improperly Delimited | Phrases Incorrectly Identified | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Total | Errors By Phrase Type | | | | | |
| | | | | | | | NOMP | VRBP | PRPP | ADJP | ADVP | Other |
| 76 | 3 | | | 8 | | | | | | | | |
| 77 | 5 | 2 | 2 | 15 | 2 | | | | | | | |
| 78 | 3 | | | 7 | | | | | | | | |
| 79 | 1 | | | 4 | | | | | | | | |
| 80 | 1 | | | 2 | | | | | | | | |
| 81 | 3 | 1 | 1 | 1 | 1 | 1 | | | | 1 | | |
| 82 | 3 | | | 3 | | | | | | | | |
| 83 | 4 | 1 | 1 | 8 | 1 | 1 | | | | 1 | | |
| 84 | 2 | 1 | 1 | 8 | | 1 | | | | 1 | | |
| 85 | 2 | | | 4 | 1 | 1 | | | | | 1 | |
| 86 | 1 | | 1 | 3 | | | | | | | | |
| 87 | 5 | 2 | 2 | 15 | | | | | | | | |
| 88 | 1 | | | 3 | 1 | 1 | | | | 1 | | |
| 89 | 1 | | | 3 | | | | | | | | |
| 90 | 2 | | | 5 | | 1 | | 1 | | | | |
| 91 | 1 | | | 3 | 1 | 1 | 1 | | | | | |
| 92 | 1 | | | 5 | 1 | | | | | | | |
| 93 | 2 | | | 10 | | | | | | | | |
| 94 | 2 | | | 3 | | | | | | | | |
| 95 | 1 | | | 6 | 1 | 1 | | | | 1 | | |
| 96 | 1 | | | 3 | | | | | | | | |
| TOTAL | 205 | 27 | 42 | 663 | 49 | 39 | 6 | 14 | 4 | 9 | 6 | |
| % | | 13% | 24% | | 7% | 6% | 15% | 36% | 10% | 23% | 15% | |

"The Clavichord and How to Play It"

| Sentence Number | Correct Number of Clauses | Number of Clauses not Identified | Number of Clauses Improperly Delimited | Correct Number of Phrases | Number of Phrases Improperly Delimited | Phrases Incorrectly Identified | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Total | Errors By Phrase Type | | | | | |
| | | | | | | | NOMP | VRBP | PRPP | ADJP | ADVP | Other |
| 1 | 1 | | | 5 | | | | | | | | |
| 2 | 2 | | 1 | 10 | 1 | 2 | | | | 2 | | |
| 3 | 2 | | 2 | 9 | 2 | 1 | | | | | 1 | |
| 4 | 3 | 2 | 1 | 9 | 2 | 2 | | 1 | | | 1 | |
| 5 | 4 | 1 | 1 | 14 | 2 | 2 | | 2 | | | | |
| 6 | 1 | | | 13 | 2 | 4 | | 1 | | 1 | | 1 |
| 7 | 2 | 1 | 1 | 10 | 3 | | | | | | | |
| 8 | 2 | 1 | 1 | 8 | 2 | 3 | 1 | 2 | | | | |
| 9 | 2 | | 2 | 12 | | | | | | | | |
| 10 | 2 | | 2 | 11 | 3 | 1 | | | | 1 | | |
| 11 | 2 | | 2 | 8 | | 1 | | | | | 1 | |
| 12 | 2 | | 2 | 3 | 1 | 1 | | | | | 1 | |
| 13 | 1 | | 1 | 9 | 1 | 1 | | 1 | | | | |
| 14 | 2 | | 1 | 9 | 2 | | | | | | | |
| 15 | 5 | 2 | 2 | 6 | | | | | | | | |
| 16 | 1 | | 1 | | | | | | | | | |
| 17 | 2 | 1 | 1 | 6 | 3 | 1 | | 1 | | | | |
| 18 | 1 | | 1 | 4 | | | | | | | | |
| 19 | 3 | | 1 | 14 | 2 | 2 | | 1 | | 1 | | |
| 20 | 1 | | 1 | 7 | | 1 | | | | 1 | | |
| 21 | 1 | | 1 | 4 | 1 | | | | | | | |
| 22 | 2 | | 1 | 11 | | 1 | | | | | 1 | |
| 23 | 3 | | 1 | 11 | 1 | 2 | | | | 1 | | 1 |
| 24 | 2 | | | 7 | | | | | | | | |
| 25 | 2 | | 1 | 11 | | | | | | | | |

"The Clavichord and How to Play It"

| Sentence Number | Correct Number of Clauses | Number of Clauses not Identified | Number of Clauses Improperly Delimited | Correct Number of Phrases | Number of Phrases Improperly Delimited | Phrases Incorrectly Identified | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Total | Errors By Phrase Type | | | | | |
| | | | | | | | NOMP | VRBP | PRPP | ADJP | ADVP | Other |
| 26 | 2 | | | 8 | | | | | | | | |
| 27 | 3 | | | 12 | 2 | 2 | 2 | | 2 | | | |
| 28 | 4 | | 1 | 9 | | | | | | | | |
| 29 | 2 | | 1 | 11 | 2 | 2 | | | | 2 | | |
| 30 | 2 | 1 | 1 | 6 | 2 | 3 | 1 | 1 | | | | 1 |
| 31 | 2 | | 1 | 7 | 1 | 1 | | | | | | 1 |
| 32 | 4 | 1 | 2 | 12 | 2 | 2 | | | 1 | | | 1 |
| 33 | 3 | | 1 | 13 | 1 | 2 | | 2 | | | | |
| 34 | 4 | 1 | 1 | 16 | 3 | 1 | | 1 | | | | |
| 35 | 1 | | | 3 | | 1 | | | | | 1 | |
| 36 | 3 | 1 | 1 | 8 | 1 | 1 | | 1 | | | | |
| 37 | 6 | 2 | 2 | 23 | 1 | 1 | | 1 | | | | |
| 38 | 1 | | 1 | 6 | | 1 | | | | | 1 | |
| 39 | 3 | | | 11 | 2 | 1 | | 1 | | | | |
| 40 | 2 | | 1 | 12 | 2 | 1 | | | | | | 1 |
| 41 | 4 | | 1 | 14 | 1 | | | | | | | |
| 42 | 3 | 1 | 1 | 7 | 1 | 2 | | 2 | | | | |
| 43 | 4 | 1 | 3 | 14 | 3 | 2 | | 1 | | | 1 | |
| 44 | 4 | 1 | 1 | 13 | 2 | 1 | | 1 | | | | |
| 45 | 1 | | | 5 | | | | | | | | |
| 46 | 1 | | 1 | 5 | 2 | | | | | | | |
| 47 | 2 | 1 | 1 | 7 | 1 | 2 | 1 | 1 | | | | |
| 48 | 2 | | | 8 | 1 | 1 | | 1 | | | | |
| 49 | 3 | 1 | 2 | 10 | | | | | | | | |
| 50 | 3 | | 1 | 13 | 3 | | | | | | | |

"The Clavichord and How to Play It"

| Sentence Number | Correct Number of Clauses | Number of Clauses not Identified | Number of Clauses Improperly Delimited | Correct Number of Phrases | Number of Phrases Improperly Delimited | Phrases Incorrectly Identified | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Total | Errors By Phrase Type | | | | | |
| | | | | | | | NOMP | VRBP | PRPP | ADJP | ADVP | Other |
| 51 | 4 | 2 | 2 | 15 | 3 | 2 | | 2 | | | | |
| 52 | 1 | | | 5 | 2 | | | | | | | |
| 53 | 2 | | 1 | 4 | 1 | | | | | | | |
| 54 | 1 | | | 4 | | 1 | 1 | | | | | |
| 55 | 5 | | 1 | 14 | 2 | | | | | | | |
| 56 | 3 | | 1 | 9 | | 1 | | | | | 1 | |
| 57 | 1 | | | 4 | 1 | | | | | | | |
| 58 | 1 | | 1 | 5 | 1 | | | | | | | |
| 59 | 2 | | 1 | 16 | 3 | 2 | 1 | 1 | | | | |
| 60 | 1 | | | 5 | | | | | | | | |
| 61 | 3 | | | 8 | 1 | | | | | | | |
| 62 | 1 | | 1 | 5 | | | | | | | | |
| 63 | 2 | | 1 | 8 | | 1 | 1 | | | | | |
| 64 | 1 | | 1 | 5 | 1 | 1 | 1 | | | | | |
| 65 | 1 | | | 8 | 2 | | | | | | | |
| 66 | 1 | | 1 | 4 | 2 | 1 | 1 | | | | | |
| 67 | 1 | | 1 | 6 | 1 | | | | | | | |
| 68 | 3 | | | 15 | 1 | 2 | 1 | | | | 1 | |
| 69 | 5 | 2 | 2 | 2 | 14 | 2 | 2 | | 1 | | 1 | |
| 70 | 2 | | | 8 | | | | | | | | |
| 71 | 3 | | 3 | 12 | 1 | | | | | | | |
| 72 | 2 | | 2 | 11 | 1 | 1 | | | 1 | | | |
| 73 | 1 | | 1 | 5 | 1 | | | | | | | |
| 74 | 3 | | 2 | 14 | 1 | 1 | | 1 | | | | |
| 75 | 1 | | | 5 | 1 | | | | | | | |
| TOTAL | 170 | 22 | 74 | 673 | 88 | 67 | 8 | 30 | 3 | 8 | 15 | 2 |
| % | | 13% | 50% | | 13% | 10% | 12% | 45% | 4% | 12% | 22% | 3% |

# APPENDIX F

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